# POWER

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# The Millennium

By Berton Braley

WHEN the dream of every toiler
In the power plant comes true,
When we get the perfect boiler
And the ultra perfect flue,
When the perfect coal comes shooting
Swiftly down the perfect slide,
When the perfect whistle's tooting
In a hoot of perfect pride;

When some superman, omniscient,
Finds a way of piping steam
Which is flawlessly efficient
As the best that we can dream,
When the perfect valve 's invented
And the perfect piston 's cast
And the perfect belt 's presented
To a waiting world at last;

WHEN the perfect engine's sighted
In the perfect engine room,
And the perfect lights are lighted,
Making brilliance out of gloom,
When, in some good time that's coming,
Just the date nobody knows,
We shall hear the happy humming
Of the perfect dynamos;

When the perfect radiators
Work without a bang or throb,
And the perfect elevators
Keep forever on the job—
Then, and not till then, and never
Any other time or year,
Shall we ever, ever, ever
Find the Perfect Engineer!

# Combining Power, Heating and Ventilation—I

By Ira N. Evans*

*SYNOPSIS—A comparison of the usual blower system and a combination system, part blower and part direct radiation, supplied with hot water under forced circulation. The advantages of combining the heating, ventilating and power loads. Purchased vs. generated power and the cost of ventilation.*

The ensuing discussion is intended to show how a minimum over-all operating expense may be attained by properly combining power, heating and ventilating equipment. The arrangement described is applicable to any large industrial plant or group of buildings where central power and heating are desirable and where the engine units are sufficiently large to warrant condensing equipment if no heating or ventilation were involved. Comparisons are made between the usual methods of arranging equipment and those advocated to accomplish the object mentioned, as applied to the plant shown in the accompanying illustration.

The first installment of this article will deal with the advantages and disadvantages of the various arrangements, while the second will be devoted to the comparative operating expense in tabular form, so arranged that the arithmetical operations may be easily followed.

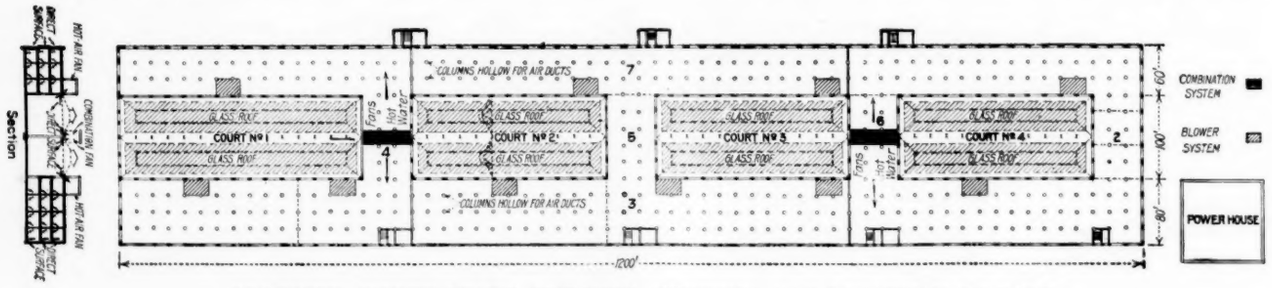
Two methods of heating are compared—one the usual fan-blower system with steam distribution, and the other a combination of fan blowers and direct radiation with forced hot-water circulation. The data for the fan system were from the design submitted by a prominent manufacturer and may be considered the best practice in this line of work. The quantities for the combination system were obtained from actual observed results in the operation of a large industrial plant with this type of system. Comparisons are made of both systems, with live steam for heating and with exhaust steam in connection with power generation, with and without ventilation.

By increasing the initial boiler pressure the possible power derived from the heating steam is determined in all cases by the maximum average load that can be carried during the higher outdoor temperature periods with a minimum use of steam not required for heating. The power is treated as a byproduct of the heating rather than the opposite relation.

In the illustration of the building, the positions of the ten fan units needed for the blower system are shown crosshatched. These fans are capable of handling 600,000 cu.ft. of air per minute. The black solid squares show the four blowers required for the combination system, which have a capacity of 300,000 cu.ft. of air per minute. In addition there is approximately 40,000 sq.ft. of direct radiation on the outside walls and under the glass roofs of the courts. The air is recirculated, or outdoor air may be used for ventilation up to 200,000 cu.ft. per min. in either case. Hot-water indirect stacks are connected to the same hot-water mains that serve the direct radiation. The hot-water mains are left uncovered and utilized as direct heating surface, as the circulated water is regulated in temperature at the power house according to the schedule. The separate heaters provided for exhaust and live steam are connected in series with the pumps and hot-water mains; the same boiler power provides steam for heating and power.

Except for the size of the exhaust heaters, the arrangement of apparatus and piping in the building is precisely the same whether power is generated or purchased, and will cost the same for installation. The live steam heater is designed for high-pressure steam and connected so as to utilize full boiler pressure with gravity return for all live steam used, direct to the boilers without pumping. The exhaust heater is arranged to condense the steam for the circulating pump only, in the case of purchased power. When power is generated, a larger exhaust heater is provided, of sufficient capacity to condense the steam for power under partial vacuum. This heater would then be placed in the exhaust line between the engines and the condenser. This arrangement permits the same distributing system to be utilized for transmitting heat from high-pressure live steam or exhaust steam under vacuum in separate heaters with the maximum efficiency and minimum waste, as no steam is carried outside the power house.

The indirect stacks of the blower system are supplied with high-pressure steam and small mains when the fans are operated with purchased current or with individual fan engines. The design contemplates the use of the exhaust steam from each fan engine for heating its own unit. In the case of power generation, large exhaust mains would be required, increasing the expense of both installation and pipe insulation to a great extent. This arrangement precludes the use of condensing equipment,




PROPOSED THREE-STORY BUILDING, SHOWING FAN LOCATIONS ON ROOF

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owing to back pressure. The larger mains increase the losses by radiation and are uneconomical for the use of live steam at reduced pressure, which is required about two-thirds of the time when the engines are inoperative.

Both systems contemplate the use of hollow building columns with distributing ducts on the roof, with the exception that the hot-water combination system would require only one-half the capacity of the blower system. To calculate the steam and fuel, a table of hours was compiled from the weather bureau reports giving the number of hours for each 10-deg. period of outside temperature from 0 to 60 deg. for days when exhaust steam from the power load is available and also for nights, Sundays and holidays when live steam operation is obligatory for heating. This table was compiled for the New York district, but in colder climates the results would be bettered owing to longer periods of lower temperatures. In comparing power generation to live-steam operation, the power generated is charged at the rate of 1¼c. per kw.-hr., as it would have to be purchased in the case of live-steam operation for heating. The price would have to be reduced below 1c. per kw.-hr. before purchased current would be a close issue.

All steam rates for power generation are reduced to a kilowatt basis at the point of service. Evaporation from and at 212 deg. is placed at 8 lb. with coal costing $4 per ton of 2000 lb. Higher prices of fuel would raise the cost of heating and ventilation a like amount for all methods compared.

### Difficulty in Comparing Costs

It is customary for manufacturers to sell fans, heaters and engines direct to the owner, leaving the ducts, piping, fanhouses, etc., to be estimated or let under other contracts, so that the entire cost is not really known until the plant is completed and the primary outfit has a comparatively low cost. The hot-water system would have to be covered complete in one contract.

In all systems generating power in the manner described, it should be remembered that a large part of the operating expense is for fixed charges which may be covered by long-term securities such as stock or bonds, while the system requiring the purchase of current involves a yearly tax of large proportion in cash to outside corporations. In the one case it is payable to the stock and bond holders as interest and dividends, while in the other it is dividends for an outside company.

In the case of the hot-water combination system with power generation, 75 per cent. of the fuel is required for heating. The power is a byproduct and requires little additional fuel. The same arrangement of apparatus is used for the hot-water system whether current is purchased or not, and if at any future time it is desirable to generate current, the only additional expense would be for heaters in the power house with no changes in the building.

With the fan system the whole heating plant would have to be modified at a prohibitive cost for alterations and additions in order to utilize the exhaust steam at low enough pressures. If arranged for exhaust steam at first, the large mains would result in large radiation losses and a heavy annual charge on the initial investment.

Some of the basic reasons why the combination system with power generation gives low operating costs are as follows: The plant may be operated for power on a condensing basis during the entire year and a large portion of the time on fuel used for heating. The heating system operates as a condenser owing to its ability to utilize exhaust steam at pressures below atmosphere, and the variation of the circulated water to meet outside weather changes gives a minimum fuel expense for heating.

When a large industrial plant is contemplated, a heating system of some type must be provided. The buildings may be heated by steam, hot water under forced circulation with direct heating surface or with indirect heating stacks, or by blowers, with equal satisfaction from a purely heating standpoint. All kinds of trouble may be experienced with any one of these systems if it is improperly installed or skimped to meet the keen competition generally demanded by the purchaser.

### Temperature of Medium Influences First Cost

The lower the temperature of the circulating medium the greater the first cost of the apparatus as well as its bulk. When live steam only is required for heating or where there is no exhaust steam available from power generation, it makes little difference what system is used provided the medium has a comparatively wide range in temperature in order to meet the changes in outside weather conditions. A high initial temperature for the circulating medium is no disadvantage, as it reduces the first cost of the system, and the operating economy is dependent far more on the proper management than on the type of system, provided it has been properly designed and installed.

The hot-water combination system is capable of the most economical operation because of the flexibility of both the air and the water to meet outside weather variations. The blowers may be shut down in moderate weather, making a big reduction in heating cost as well as power. The greatest objection to the blower system is the high peak load on the boilers in extreme weather, due to the fans causing a greater interchange of the air of the building with that outside and the high initial air temperature required. These difficulties are avoided with the combination system. In moderate weather the fans may be shut down and the heat drawn from the direct radiation. In extreme weather both the fans and direct radiation provide ample capacity. A great saving is thus effected, as the heat consumption of the systems usually employed cannot be reduced much below one-third of the maximum capacity, which is more than is required in moderate weather.

### Lack of Capacity Cause of Trouble

The heating system should be viewed as a conduit to transfer the heat of the boiler or other source to the building. In most cases of unsatisfactory heating the trouble may be due to insufficient capacity, but is generally the result of cheap building construction and leaky windows. The owner complains and requires the contractor to increase the capacity of the heating system, thus burning more fuel and adding to the owner's operating expense. There are numerous buildings with a large proportion of the wall surface made up of 2-in. concrete on expanded-metal lathing with tile roofs. The transmission of these surfaces is as great as glass, and the coal consumption for heating is increased accordingly. A sheathing of insulating material, wood or plaster, with

an air space, would not add materially to the weight and would reduce the coal consumption one-quarter to one-third, increasing the heating capacity correspondingly. The cost would easily be saved in fuel in a short time.

The question of generating or purchasing power should be determined at the outset. In certain cases the purchase of current may be the proper course for the owner to pursue, but the heating equipment should be such that at any future time power may be generated and exhaust steam utilized for heating with a minimum expenditure. The use of the hot-water combination system will answer these requirements, as a minimum operating cost is attained on live steam if current is purchased, and power generating machinery may be added readily, utilizing the exhaust steam with practically no changes in the system within the building proper.

### Economy of Heating with Exhaust Steam

In generating steam, about 80 per cent. of the heat is required to change the water into a vapor, and the same heat, known as latent heat, has to be dissipated before the steam will revert back into water. Herein lies the economy in the use of exhaust steam for heating.

The least expenditure of fuel that will give the highest pressure will be the most economical for the engine, as the latent heat has to be provided in all cases before the steam is in condition to be utilized for power. Also the lowest pressure and temperature to which the steam is cooled will give the greatest economy in the engine.

The adequate warming of all buildings involves the dissipation through the walls and windows of the entire heat supply, sufficient to maintain a comfortable temperature in the rooms of from 60 deg. to 70 deg. in all weather from 0 deg. and below to 60 deg., and is a cooling effect varying from the maximum to nothing with the outdoor temperature. The latent heat of steam is nearly the same per pound for all pressures near atmosphere and below and is the portion utilized for all steam heating. The most economical engine operation for power requires the latent heat from the exhaust to be dissipated and the steam condensed to produce any vacuum or pressures below the atmosphere on the exhaust side of the engine; the quantity varies with the power requirements.

It is readily seen that the heating and power may be made complementary functions by utilizing the cooling effect of the heating system to condense the exhaust steam at pressures below atmosphere, thus producing a partial vacuum on the engines.

### Using Exhaust at Low Pressure

The use of exhaust steam at atmosphere and temperature above 212° for heating, however, becomes a drawback rather than an adjunct to the power generation. This makes the hot-water distributing system the only method of utilizing the heat from exhaust steam at low temperatures. At the same time the lower the temperature of the heating medium in extreme weather the more costly the installation of the heating system.

The use of the combination system of blowers and direct radiation holds down the first cost and insures economy. A vacuum of 20 in. and a water temperature of 160 deg. can be maintained in all average winter weather, and with a water temperature of 212 deg. in zero weather, the same capacity is obtained as with low-pressure steam without the high peak load of the blower system.

It is impracticable and expensive to distribute steam at temperatures below 212 deg., because of the increased volume of the vapor per pound, and with larger mains there is difficulty in maintaining them air-tight. The latter feature is absolutely necessary in operation, as very small air leaks destroy the vacuum.

A low-pressure steam system of distribution is more costly to install and operate than a high-pressure system when with the engines inoperative live steam has to be used a large part of the time. Because of having two heaters, one for exhaust and one for live steam at high pressure in the same water circuit, the hot-water system of distribution operates as economically on live steam as on exhaust steam. The live-steam heater may be so placed as to obtain a gravity return to the high-pressure boilers from which the engines are operated, with the attendant saving over reducing the pressure through a main of large diameter and great length. This saving may be as high as 10 to 15 per cent. in favor of the hot-water system over steam distribution, as the operation of the feed pump is avoided as well as additional heat for boiler-feed water. The water system having mechanical circulation is independent of the temperature of the medium, which is not true of steam, as it circulates by a drop in pressure produced either by a vacuum pump and cooling water or by raising the back pressure on the engines.

### Special Consideration of Risk Unnecessary

The author has not discussed the old threadbare trade arguments in connection with hot-water systems, of freezing and bursting, as their presence in the article would simply indicate a lack of good engineering. If there is no heat in the building, sprinklers and plumbing will freeze first regardless of the heating system, and with adequate testing the question of bursting is on a par with operating a boiler at low pressure to generate power for the same reason.

Ventilation or the use of outdoor air for heating is a luxury, and owners seldom know what it costs, although it is the same for all systems considered. In most large manufacturing buildings the cubic contents per operative and the window leakage are so great that recirculation of the air for heating would be ample without the use of outdoor air for ventilation.

Where special manufacturing operations require ventilating, it should be provided in any case by a separate system independent of the heating plant. The argument of using fans for cooling in summer is largely fallacious, as the temperature inside a building of this character will probably be less than out of doors. The use of air washers and cold water will cool the building to some extent at considerable expense, but with all windows and doors open, it is much like trying to cool the surrounding country. Whether the air is cooled or not, the operatives will not stand for closed windows in summer, as they think they are more comfortable with them open.

When the utmost cooling effect is desired of a heating system to dissipate the heat from the power steam, as in the combination system, ventilation may be had at practically no expense, as in that case it increases the quantity of heat dissipated, but does not necessarily raise the temperature of the heating medium to do it. The combination system permits of very low temperatures of the circulated medium with moderate first cost of installation and a wide range in the quantity of heat dissipated.

The use of hot water with blowers only, although feasible, was not considered in the comparison on account of the prohibitive first cost and the improbability of using water at low enough temperature to insure a good vacuum.

Fairly high temperatures of air have to be used for fan heating, and where the ducts are within the building, the losses by radiation from them overheat one portion of the building in order to reach the distant points with air at the required final temperature. The preferred arrangement of the combination system is to take the fan supply for recirculation at the points where the air of the building is hottest and discharge it at the floor level, where the temperature is lowest. The lower air temperature requirements of 90 deg. in 0 deg. weather for the combination system as against 120 deg. for the blower system results in reduced duct losses. The direct radiation on the outside walls causes better diffusion as the warmer air comes in contact with cold walls and glass surfaces with great reluctance, but rises to the ceiling level.

### Getting Rid of Air from the System

Exhausting the air from the high points, as in the courts of the building, reduces the roof temperature by several degrees, thus lessening the heat loss and saving possibly 10 per cent. of the total heat loss of the building over allowing the air to rise and be cooled by the glass roofs.

A temperature of 80 or 90 deg. has been observed under the roof of a building 60 to 70 ft. high when the floor temperature was 65 deg. When the fan was started, the room temperature at the breathing line rose 10 deg. in a very few minutes. In the combination system the water is circulated through the indirect stacks whether the blowers are operated or not, and all that is necessary to start the indirect system is to throw the switch controlling the fan motor. In this manner the horizontal ducts are filled with warm air and instantaneous results are obtained. By varying the vacuum to regulate the circulated water with the outdoor temperature, a large saving in heating steam is effected, as where the whole system is under control of the operating engineer he will take advantage of the lowest water temperature to insure the maximum vacuum on his generating units.

### Regulation of Water Temperature Is Easy

The changes in vacuum are required only two or three times a day with changes in the outdoor temperatures and the power load. All that is observed is the return water and outdoor temperatures, the former being adjusted in accordance with a pre-arranged schedule. The remainder of the operation influencing the vacuum, steam rate and the balance of power and heating follows automatically. This regulation is analogous to the field rheostat on a dynamo to regulate the voltage with the load.

The usual idea of utilizing exhaust steam has gone no further than that there should be a balance between power and heating in zero weather—this temperature in New York prevailing about one per cent. of the heating season—and that all exhaust steam shall pass outboard under back pressure slightly above atmosphere, and all units are operated under the same back pressure. With hot-water heating under forced circulation, the arrangement of heaters and condensers contemplates the use of full vacuum, say 28 in., on any power not needed for heating and partial vacuum on the remainder. Two vacuums may be carried on the same system with one condenser.

Thermostatically controlled rooms or buildings are regulated by changes in the room temperatures, which may not occur for several hours after the outdoor temperature has increased or diminished. By regulating the water temperatures from observations of the outdoor thermometer, the heat supply is varied at the time the weather changes, regardless of the building, thereby economizing heating steam by anticipating the increase or decrease of the heat loss of the building.

The tables and calculations comprising the next installment of this subject show how the vacuo hot-water system gives the maximum power and vacuum, a minimum steam consumption for heating and power and a moderate first cost of installation. By approaching the heating and power problem in this manner, highly favorable results are obtained in comparison with vacuum steam heating and noncondensing operation. The combination system gives temperature regulation without automatic control and hot water at the price of steam.

## Soot in Fire-Tube Boilers

By A. J. Dixon

Among the difficulties that an engineer encounters in seeking economy in the power plant is the soot problem. Every operation in the running of a power plant is potential of waste, but for the most part the possible avenues of waste are so apparent to good management that full precautions are taken. Soot, however, is one obstacle to economy that often deceives the engineer into regarding it as a matter of small consequence by contrast with some of the other features of furnace performance, when as a matter of fact it is of the first importance, demanding careful attention.

Most uptodate installations of water-tube boilers include a permanently applied soot-blowing apparatus. These devices are variously designed, but they all serve the same purpose—to effectively remove the soot from surfaces partly or wholly inaccessible with the ordinary steam hose and nozzle, and to afford a means for doing the work more frequently and with less bother than is practicable with the old-fashioned equipment.

Where fire-tube boilers are used, dependence is placed more often upon the old-style method; although the economy of the fire-tube boiler is on the whole more rapidly impaired by deposits of soot than is the case with the water-tube boiler.

How many engineers know with any degree of certainty how the presence of soot on the boiler surfaces figures in the annual expense of running the plant? It is difficult to determine this cost without doing a little experimenting. In one case where the engineer made an intelligent effort to learn the extent of loss due to negligence in attending to the sooty surfaces of a fire-tube boiler, some interesting results were revealed. The test was made with a horizontal return-tubular boiler, conventionally built and set, which furnished steam for a factory engine developing an average of about ninety horsepower during a daily run of ten hours. The total available cross-section of the tubes was found to have been diminished to practically one-third of the original area by the soot accumulating during a four-days' trial; the normal heat-absorbing capacity of the boiler having been reduced in this interim of neglect nearly 70 per.

cent., while the average coal consumption per horsepower per hour was almost doubled.

These figures are not offered as approximating an invariable standard of depreciation in this particular, because the available draft, the character of the fuel, the method of firing, the condition of the boiler internally, are all modifying factors in individual cases. The results in this instance are given simply to point the fact that the loss from soot is an accelerating waste which speedily mounts into figures beyond the estimate which the man on the job ordinarily puts upon it.

A fire-tube boiler's facility for making steam diminishes only slightly with thin deposits of soot newly gathered upon the clean surfaces, but the fuel consumed is materially increased. This disparity between the economy and steaming effectiveness is readily explained. The thin layers of soot freshly accumulating in the tubes cause a proportionate impairment of the efficiency of heat transfer through the metal, and at the same time retard the draft by cutting down the total available area of flue section. The immediate demand is for a higher furnace temperature, both to stimulate the transference of heat through the still unaffected shell surface and to restore the draft to normal by producing a higher stack temperature. Thus for a time the increased activity of the shell surface balances the loss of flue area and effectiveness of tube surface and the steaming efficiency of the boiler continues apparently unaltered, though actually at the expense of a considerable increase in the quantity of fuel consumed. As the tubes fill up with soot, however, a condition quickly develops wherein the steaming capacity of the boiler can be maintained only by exercising extreme care in handling the excessive quantity of fuel used, and in a number of cases it is only this difficulty of manipulation that awakens the operating man to proper cognizance of the soot evil, and that only for the time being.

# Reconnecting Induction Motors—Diagrams of Uncommon Open-Slot Windings

By A. M. Dudley

*SYNOPSIS—Diagrams of some of the less common forms of open-slot induction-motor windings are given and discussed. The importance of these windings lies in the fact that they may be used to make a temporary workable connection that will pull a job through until such time as a permanent connection can be made.*

The preceding article[1] discussed the usual forms of connection for windings using "diamond" coils in open slots. It is the purpose of this article to present some of the less usual forms. These are often of more importance in reconnecting old machines than are the standard forms, because it is by their help and "judicious" use that a job is pulled through in a hurry or a temporary workable connection made that will carry on an essential part of a larger work until such a respite can be obtained as will allow a more permanent connection.

The word "judicious" is used for the reason that short-cut methods of this type are sometimes used where there is no need for them and where their use is a positive detriment, since the extra operating expense caused by them soon offsets any immediate apparent gain. Such a case, for example, would be represented by reconnecting a three-phase 440-volt series-star winding for two phase 440 volts with the same coils, making no other change. The machine would probably operate in many cases, but the increased power bill would pay the interest on a considerably larger sum than would be represented by the cost of a proper set of two-phase coils. If this point is understood and given proper consideration, it is desirable to know some of these semistandard or possible schemes, as they may be of service in an emergency.

Among these schemes one which is not usually found in textbooks, but which is perfectly legitimate and largely employed by all manufacturers, is the use of a core having a number of slots that is not an exact multiple of the number of phases times the number of poles—for example, a 90-slot core wound for three-phase, eight poles. This connection is represented by Fig. 1. The Roman numerals on each pole-phase group represent the number of coils in that group, and it will be seen that each phase consists of 6 groups of 4 coils each and 2 groups of 3 coils each, or a total of 30 coils, and 90 coils in the complete winding. This irregularity introduces a slight displacement of the phase angle at certain places, but these places are so chosen around the machine that the net result is a perfectly balanced three-phase voltage at the terminals of the machine. E. M. Tingley originated an ingenious and simple method for arranging such windings with mathematical accuracy to give perfectly balanced voltage[1].

It does not follow, however, that only the slot numbers recommended by Mr. Tingley can be made to give operating results. Other combinations are practically workable along the same general lines and can be laid out by inspection with reasonable regard to the best symmetry. But it is true that only the combinations pointed out by him can be made to give a theoretically perfect voltage balance at the motor terminals on all phases. This explanation is made in reply to the question frequently asked as to whether it is essential that the number of primary slots shall be a multiple of the number of phases times the number of poles. It does not necessarily have to be such a multiple, and connections of the type shown in Fig. 1 give practically as good operating results as any other.

The manufacturers make use of this type of connection in order to use the same core for as many combinations of phase, voltage, poles, cycles and horsepower as possible, thereby greatly reducing the stock of punchings or stampings that must be carried and also the expense necessary for dies to produce these punchings.

Particular reference is made to such diagrams in this article to insure that no one who is contemplating a reconnection need be discouraged or give up the attempt if

[1]"Power," Apr. 17, 1917.

[1]In the "Electrical Review" for Jan. 23, 1915, Vol. LXVI, pp. 116-8.

it is discovered that the number of pole-phase groups does not divide exactly into the number of slots. In general, if the total number of coils in the winding is right for the voltage to be used, it will be satisfactory to put as many coils in each group as can be obtained by the even division of pole-phase groups into total number of slots and then to distribute the odd coils equally among the phases and insert them mechanically in various groups to give the greatest symmetry. Of course, if there are two or more parallels in each phase, there must be the same number of coils in each parallel. For example, in the case of Fig. 1 there are three phases and eight poles; $3 \times 8 = 24$ and $90 \div 24 = 3\frac{3}{4}$; therefore there will be four coils in each group excepting in the case of six groups which will have three coils. Two of these six groups are in each of the three phases, and one of these groups is in each of the two parallel legs of each phase. If this be followed, it may not give the perfectly balanced condition of Fig. 1, but when done by a careful man, it will usually give a safe operating condition.

A second expedient which may be employed to connect a given winding for twice the original number of poles is the use of what is known as a "consequent-pole" connection. This is illustrated by Figs. 2 and 3, which show

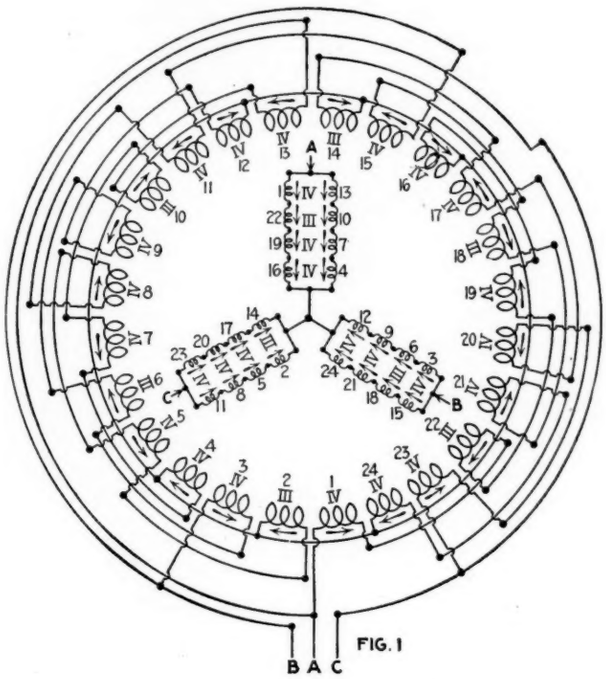



FIG. 1

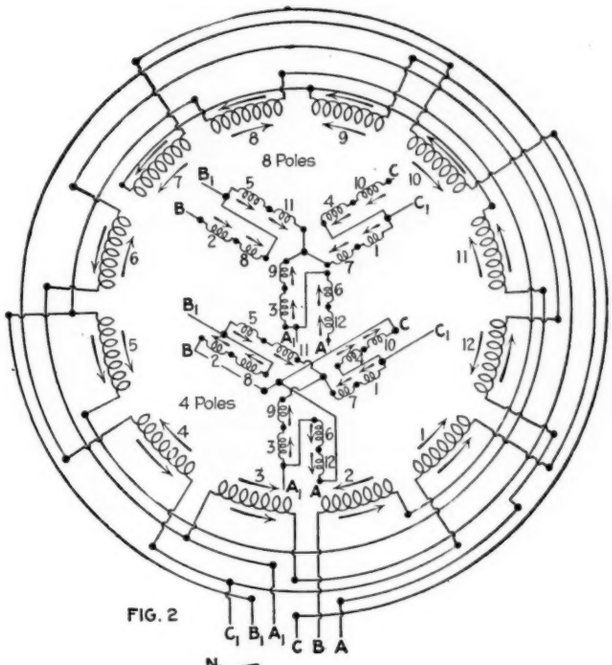



FIG. 2

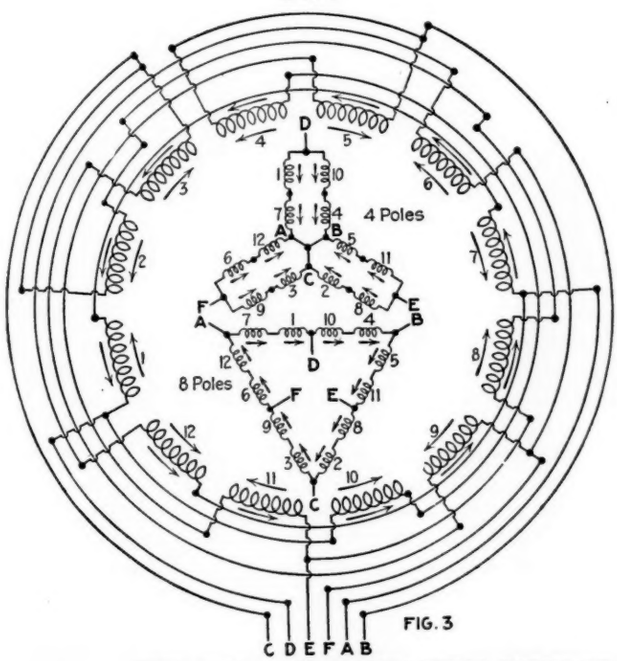



FIG. 3

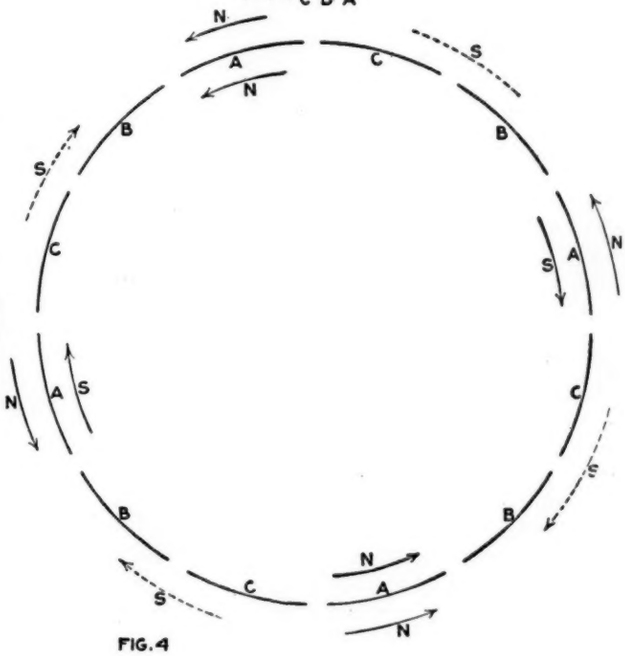



FIG. 4

FIGS. 1 TO 4. SHOW LESS USUAL FORMS OF THREE-PHASE INDUCTION-MOTOR WINDINGS

Fig. 1—Three-phase, eight-pole, parallel-star connection with balanced phases on a machine having 90 slots. Fig. 2—Three-phase, two-speed, four- and eight-pole diagram. On four poles $A_1$, $B_1$ and $C_1$ are leads and A, B and C are connected together. On eight poles A, B and C are leads and $A_1$, $B_1$ and $C_1$ are open. Fig. 3—Three-phase, two-speed, four- and eight-pole diagram. On four poles D, E and F are leads and A, B and C are connected together. On eight poles A, B and C are leads and D, E and F are open. Fig. 4—Shows location of poles in two-speed connection shown in Fig. 2

the usual connections for a three-phase motor wound to give two sets of poles or two speeds in the ratio of two to one. This change is accomplished by a single winding. In Fig. 2 the high-speed is parallel-star and the low-speed series-star. In Fig. 3 the high-speed is parallel-star and the low-speed series-delta. Either may be used at the discretion of the designer. Fig. 2 usually gives better results where a constant torque is desired and gives twice the horsepower on the high-speed that it develops on the low-speed. Fig. 3 gives somewhat better results where a constant horsepower is desired at both speeds, as is the case with most machine-tool applications.

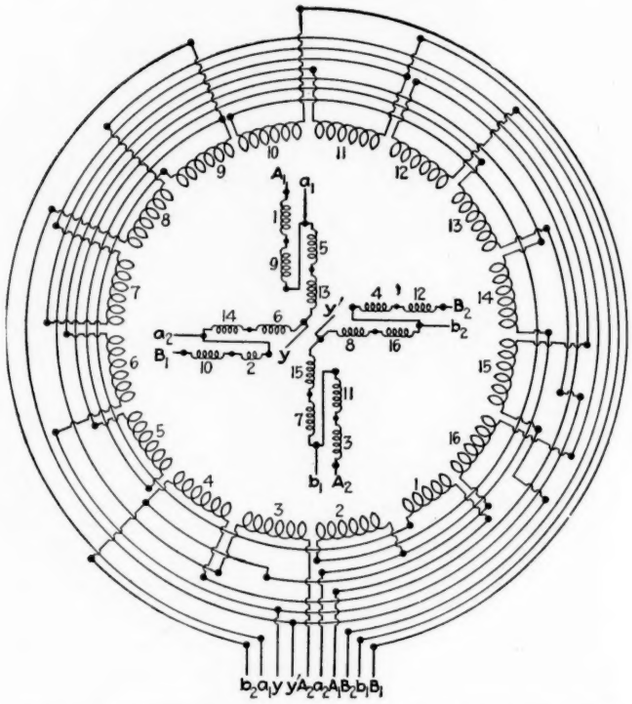



FIG. 5. CONNECTION DIAGRAM FOR A TWO-PHASE, TWO-SPEED, FOUR- AND EIGHT-POLE WINDING

For eight poles connect y to y', use $A_1$, $A_2$ and $B_1$, $B_2$ for leads and leave $a_1$, $a_2$ and $b_1$, $b_2$ open. For four poles connect $A_1$, $B_1$ together and $A_2$, $B_2$ together leave y and y' open and use $a_1$, $a_2$ and $b_1$, $b_2$ for leads

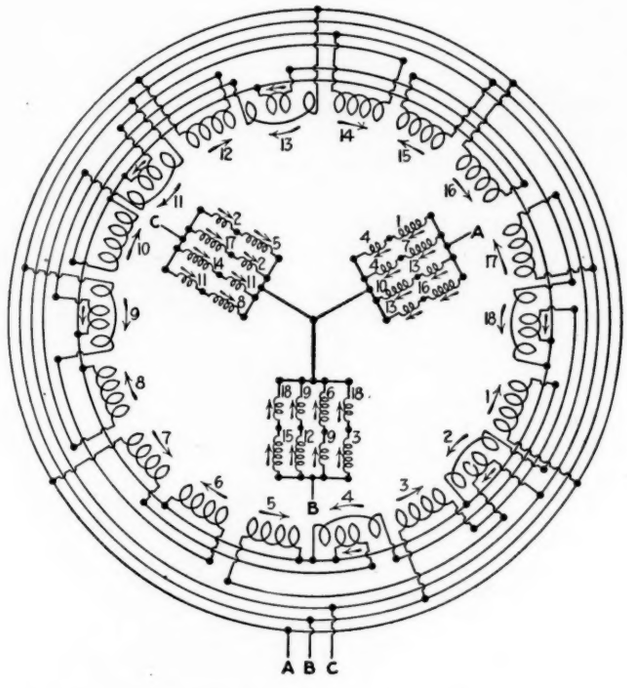



FIG. 6. CONNECTION DIAGRAM FOR A THREE-PHASE, SIX-POLE WINDING GROUPED IN FOUR PARALLELS

Connections of this general type should be used only in cases of temporary emergency as they leave the motor in an unsatisfactory operating condition even when they have been properly done

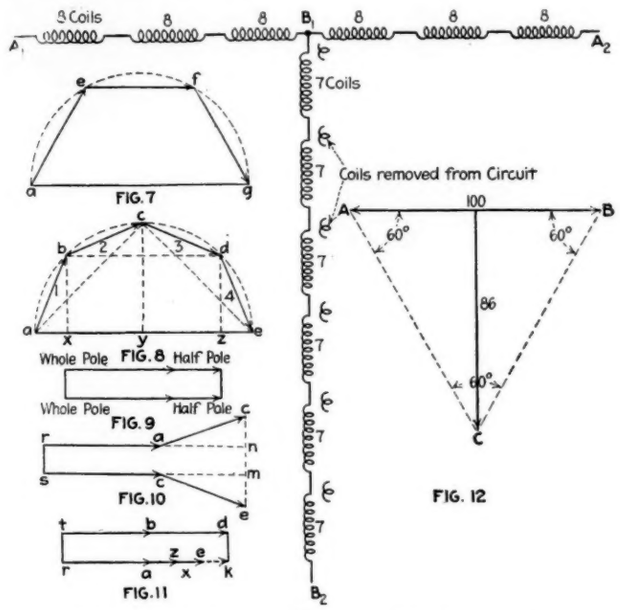
Fig. 4 is an explanatory diagram showing schematically how the two sets of poles are produced by such windings. Considered with Fig. 2, the inside set of arrows shows the parallel-star connection where four salient poles are produced directly by the winding, two north and two south. The set of arrows outside the winding circle shows the winding connected in series-star and the current direction such as to produce four north poles by the winding. Since it is not possible to have north poles alone, there immediately result four consequent south poles, indicated by the dotted arrows, where the magnetic flux returns to the primary. This results in eight poles and half-speed. For the sake of simplicity the arrows shown are for one phase only. The three phases interact to produce the combined magnetic pole as in any normal three-phase winding. These diagrams are shown to indicate that it may be possible in some cases to reconnect motors for half-speed by making use of a diagram of this nature. Such a connection, for example, makes it possible at times to reconnect a 25-cycle motor for 60 cycles and twice the number of poles, and so keep the r.p.m. of the motor nearly the same.

It will be noticed that the outside arrows on the pole-phase groups for checking the slow-speed, or eight-pole, connection in Figs. 2 and 3 all point in the same direction instead of alternately in opposite directions as the inside arrows do. This is because the eight-pole connection is "consequent-pole," or so connected that the current produced the same polarity in all the pole-phase groups, instead of alternate north and south as is usually the case. It will be recalled that in the fourth article, Apr. 17, mention was made of the fact that in such a case the check with the alternate arrows did not hold. It will be seen from Figs. 2 and 3 that in checking windings of this type, or consequent-pole, by placing arrows on the pole-phase groups in the direction from the lead toward the star in all three phases, the arrows will all point in the same direction. This can be explained in another way by saying that in a winding of this type there are only half as many pole-phase groups for the same total number of poles as there are in the usual form of winding. This is equivalent to saying that alternate pole-phase groups are omitted. Since in the check of the usual winding the arrows are alternately opposed, if alternate arrows are omitted the remainder will all be in the same direction, as is indicated in the check of the eight-pole connection of Figs. 2 and 3.

A diagram for a two-phase two-speed connection where the winding is in parallel on the high-speed and in series on the low-speed is shown in Fig. 5. This winding is of particular and especial interest in that it overcomes one of the disadvantages of the corresponding three-phase connections shown in Figs. 2 and 3 by putting half of the winding in one phase for the low-speed connection and in the other phase for the high-speed connection. This is an advantage, because the so-called

"winding factor," or "distribution factor," remains the same on both speeds as in a normal two-phase machine, while in the three-phase connections shown in Figs. 2 and 3 the winding factor is only 86.6 per cent. as good on the low-speed connection as on the high. This is because there are only four winding groups per phase spread over the entire periphery, and yet eight poles are being produced.

Expressed in another way, the coils for one of the eight poles are spread over the usual span for a four-pole machine. Since the distribution factor is a measure of the induced voltage of counter electromotive force generated, and since the capacity of the motor may be measured by its current-carrying capacity multiplied by the induced voltage, it can be concluded at once that the loss of 14.3 per cent. in the three-phase connection on the slow speed is avoided in the two-phase diagram, Fig. 5. In reality the gain is greater than this, for the reason that the two-phase distribution factor caused by consequent poles is




FIGS. 7 TO 12. VECTOR DIAGRAMS AND A T-CONNECTED WINDING

Figs. 7 to 11—Vector diagrams, showing the voltage relations in the parallel paths of the connection, Fig. 6. Fig. 12—Two-phase winding connected "T" to operate on three phase

only 70.7 per cent., as against 86.6 per cent. in the three-phase.

Speaking simply, if a series-parallel two-phase connection were used, similar to the three-phase, Fig. 2, and without changing the coils from one phase to the other as does Fig. 5, the loss in horsepower on the slow speed would be approximately 30 per cent., which is certainly a matter of prime importance. It is mechanically possible to make such an arrangement on a two-phase winding, but there seems to be no practical way of accomplishing the same result on a three-phase winding. As in the case of the three-phase two-speed diagrams, this connection shows the possibility of changing a standard motor to half-speed by the medium of such a connection.

When operating from a three-wire two-phase system or any system having the two phases interconnected in any way, all four of the leads that connect to $y$ and $y'$, Fig. 5, should be brought out instead of tying them together in pairs and bringing out $y$ and $y'$ as shown. This is in order that the phase windings may be kept clear of each other on both speed connections.

Fig. 6 illustrates a connection that is sometimes attempted, but usually with disastrous results. In all the foregoing diagrams the phase-pole group has been treated as a unit. That is to say, if there were four coils per phase and pole, these four were connected in series into a group and handled as a unit. Fig. 6, on the other hand, breaks up some of the groups into halves. Suppose, for example, that a three-phase six-pole motor has 72 coils total and is connected in series for 440 volts and it is desired to reconnect it for 110 volts. It can be parallel for 220 volts, and there will be three pole-phase groups in each of the two parallel legs of the winding. It cannot be paralleled four times, since 6 is not divisible exactly by 4. Since there are 6 poles and 3 phases, there are 18 pole-phase groups and $72 \div 18 = 4$ coils per group. It is therefore possible to split 6 of the 18 groups into halves of two coils each, and by putting a half-group in series with a whole group to get 4 parallels per phase having 1.5 pole-phase groups in each of the 4 parallel circuits. Such a connection is shown in Fig. 6. This is rather difficult to do properly unless there is an expert winder available, and it leaves the motor in an unsatisfactory operating condition when it has been done. This is explained by the vector diagrams in Figs. 7 to 11.

Let $ag$ represent the voltage vector of one magnetic pole made by combining the three pole-phase vectors $ae$, $ef$ and $fg$, Fig. 7. For clearness, one pole-phase vector $ae$ is shown in Fig. 8 drawn to a larger scale and made up of the vectors of the four separate coils $ab$, $bc$, $cd$ and $de$. The length of the line $ab$, for example, represents the voltage generated by the rotating field in a single coil of the winding, and four of them are considered together because there are four coils in series in any complete pole-phase group; as for example, group 16 in Fig. 6. If two or more circuits, each made up of one whole pole plus one half-pole, are to be connected in parallel, the two resulting vectors should be the same length and have the same direction or phase. Such a condition is shown in Fig. 9. This is a true parallel, and there will be no circulating current around the closed loop formed by the two parallels in the winding, since two equal voltages in phase with each other are opposed.

An inspection of the four vectors of which $ae$ is composed will show that it cannot readily be divided into two parts and paralleled without there being circulating current. Suppose, first, that the winding group is split in the middle at $c$, leaving $ab + bc$ for one half and $cd + de$ for the other. The two resulting vectors are $ac$ and $ce$. When each of these vectors is added to another complete pole and the two connected in parallel, the result is indicated in Fig. 10, where $ra + ac$ is paralleled with $sc + ce$. Since $ac$ and $ce$ are not in phase, there is left a voltage equivalent to $em + nc$, which will set up current around the closed loop and produce increased heating. In order to avoid this to a certain extent, the two outside coils of the group, $ab$ and $de$, are sometimes paralleled against the two inside coils, $bc$ and $cd$. The two resulting vectors $ax + ze$ and $bd$ are in parallel, but they are of different lengths. The results are shown in Fig. 11, where a whole pole $tb$ plus the half-pole $bd$ is in parallel with $ra + ax + ze$. While these vectors are in phase, the difference in their numerical value leaves a

component *ek*, which is unbalanced and which is free to cause circulating current in the closed loop of the parallel circuit.

COMPARISON OF A TWO-PHASE MOTOR CONNECTED "T" TO OPERATE ON THREE-PHASE

| | Normal Two-Phase Winding | Three-Phase "T" Connection | Normal Three-Phase Winding |
|---|---|---|---|
| Full-load efficiency | 88 | 86.9 | 88.5 |
| Full-load power factor | 89 | 84.8 | 90 |
| Starting torque | 1.75 | 1.20 | 1.94 |
| Maximum torque | 3.3 | 3.17 | 3.3 |
| Deg. C. Rise at Full Load: | | | |
| Stator copper | 22.5 | 32 | 21 |
| Stator iron | 20 | 32.5 | 19 |
| Rotor copper | 22 | 30 | 22 |

In addition to the difficulty of making this connection properly and the fact that there is at all times some circulating current, there is also likely to be trouble in keeping the phases insulated from each other. All things considered, this is an expedient which had better be left untried except in cases of emergency. For all ordinary operating conditions much better results will be secured by replacing the old coils in the machine by new coils wound for the proper voltage.

The table shows comparative performances of a two-phase motor reconnected for operation on three-phase by a "T" connection and the performance of the same motor when supplied with new three-phase coils and connected in a normal three-phase manner.

Fig. 12 shows a possible three-phase "T" connection which may be made from a two-phase winding by a method similar to the Scott transformer connection. The effect of this connection upon the performance is shown in the table and will be discussed in a later article under "Changes in Phases." It is a connection that should be used only as a temporary expedient until better arrangements can be made. It is possible to devise other makeshifts, but they are usually attended with too great a sacrifice in the heating and efficiency of the motor, that it is safer to leave them untried. It happens that a connection that looks feasible from the standpoint only of the number of coils in series, falls down on trial because these coils are not strictly in phase. Experiments of this nature are better left to the electrical manufacturing establishments.

# Operating Mechanical Stokers—II

By Warren O. Rogers

*SYNOPSIS—The underfeed type of stoker operates on the principle of forcing the fuel into a retort below the burning fuel bed, from where it is pushed upward, during which process it is coked. The directions given in this article pertain to the Jones stoker.*

So far as known, the Jones was the first underfeed mechanical stoker with which the air and fuel supply were proportioned to meet varying load demands. The older types of stoker require hand dumping and raking

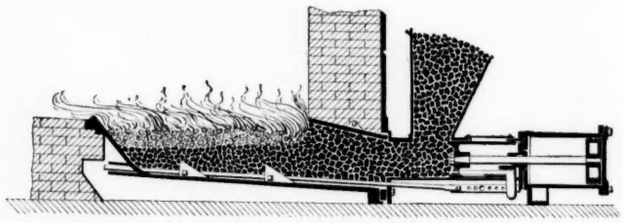


FIG. 1. SECTION THROUGH STOKER, SHOWING RAM AND PUSHER BLOCKS

of the clinkers and what ashes there may be out on the floor in front of the furnace. Recent improvements provide the latest types with automatic means for dumping the ashes and crushed clinkers into the ashpit. The average cost per rated boiler horsepower for underfeed stokers with horizontal retorts is about $4.50. They have a normal forcing capacity of 300 per cent. rating and a maintenance cost of from 4 to 6c. per ton of coal burned.

A side view of the stoker is shown in Fig. 1. Coal is fed to a hopper and is pushed forward and upward by the successive action of a ram and pusher block. The fire is always on top, and as fresh coal is slowly pushed upward, it is gradually heated until coked.

As the tuyere openings are at a point above the fresh fuel in the stoker retort, but below the fire, the volatile matter is driven off during the coking process and is mixed with the air before reaching the incandescent zone of the furnace. Fig. 2 shows a cross-section through a furnace with a single retort. Air from the blower is forced into the sealed ashpit through the duct, the supply being controlled by a blast gate in the line. From the ashpit the air passes under pressure through the hollow tuyeres into the furnace.

In combination with the stoker there is the forced-draft outfit consisting of an engine-driven fan (Fig. 3), positively controlled. The air supply is regulated regardless of the rate of fuel feed or the grade of fuel being burned.

In addition to the blower equipment there is an automatic control apparatus. First a sensitive valve is

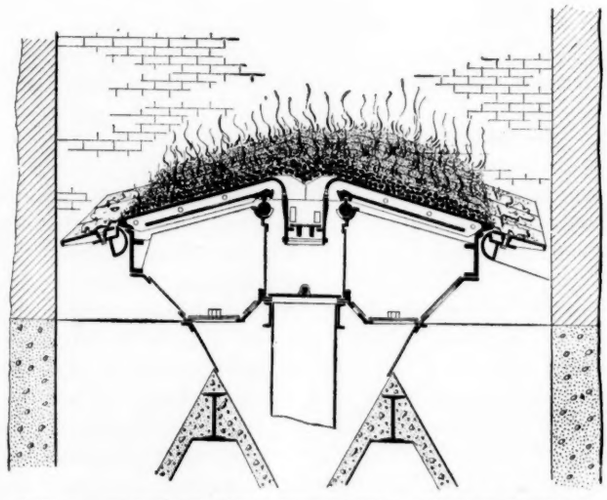


FIG. 2. CROSS-SECTION THROUGH A SINGLE RETORT

introduced into the steam line leading to the blower engine, and the engine operates the automatic valve that controls the fuel supply to the furnace. If the steam pressure drops, the regulating valve acts to increase the

speed of the engine, causing a corresponding increase in the air and fuel supply; an increased steam pressure causes an opposite action.

Each automatic control valve (Fig. 4), is equipped with a pointer the location of which indicates the rate of feed, and nine variations from 0 to 8 are provided. In emergencies the valve may be hand-operated by means of a crank that fits onto the shaft that projects through the trigger hub.

When starting a fire in this stoker without steam to operate it, shovel coal through the fire-doors in the boiler front until the stoker retort is full and the tuyere blocks are covered. Then build a wood fire on top of the green coal (Fig. 5), leaving the fire-doors open to provide a draft. Fire with wood until sufficient steam has been raised to operate the blower engine, but run the blower slowly at first, increasing the speed as the fire builds up. The wood fire can then be discontinued and the fuel fired by hand through the firing doors in the usual manner as with hand-fired grates, until enough steam is generated to operate the stoker ram; between 30 and 40 lb. is usually sufficient. After the blower is started, steam can be raised rapidly.

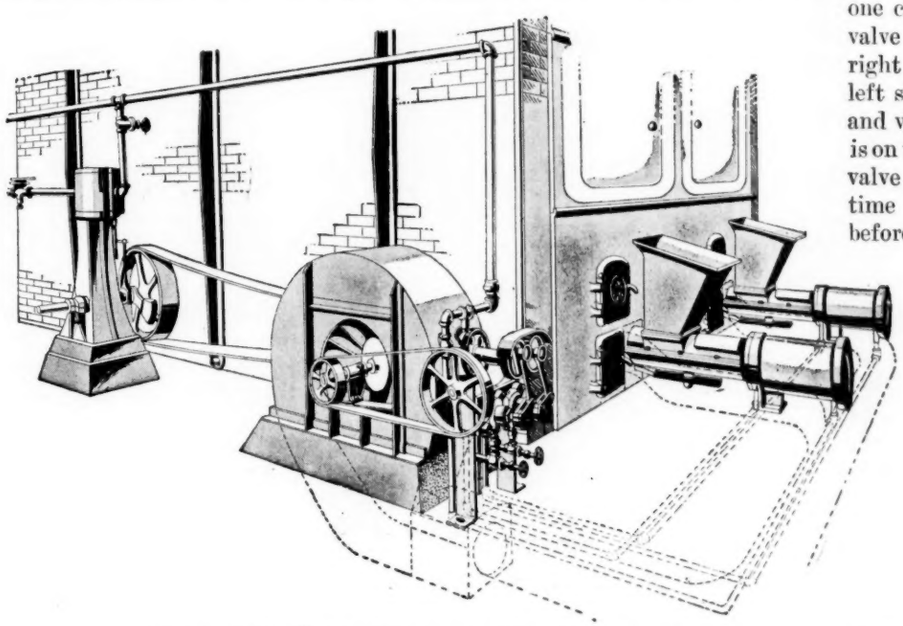


FIG. 3. FORCED-DRAFT APPARATUS AND ENGINE DRIVE

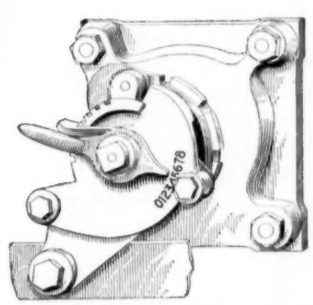


FIG. 4. AUTOMATIC CONTROL VALVE

When there is steam to operate the stokers, it is less trouble to start a fire. First fill the retort by means of the ram, so that the tuyere blocks are covered with green coal. Then scatter fire along each side and over the center of the retort, on top of the green coal. Then start the blower, slowly at first, increasing the speed as the fire is built up.

Before running the automatic attachment with the belt, always turn steam on all automatic valves and give the valve chamber time to expand before attempting to place the valve in operation, thus preventing binding due to unequal expansion. Always keep the automatic valves well supplied with oil and also keep oil in the reservoir in the valve stem.

The coal supply should be continuous and sufficient to maintain a heavy fire from 14 to 24 in. deep over the retort and of a shape approximately as shown in Fig. 2. To increase the supply of coal, set the index trigger to a higher number; never shovel coal on top of the fire. To decrease the supply of coal, set the index trigger to a lower number. To cut off the supply of coal, set the index trigger, Fig. 4, at zero.

The Cole attachment, in connection with the regulating valve controlling the speed of the engine, automatically increases the supply of the fuel and air with the demand for steam. A little practice will enable the operator to set the adjustable index trigger so as to maintain the required depth of fire.

To burn down the fire, decrease the supply of coal, but do not entirely cut it off. To build up the fires, increase the supply of coal. It is sometimes desirable on starting fires, or after cleaning, to build up the fires quickly, which may be done by operating the valve with a crank furnished for the purpose, one revolution of the valve giving one charge of coal. In operating the valve by hand, always turn it to the right when the primary valve is on the left side as one faces the attachment, and vice versa when the primary valve is on the right side. When operating the valve by hand, give the ram sufficient time to complete its forward stroke before withdrawing it for another charge. Repeated short strokes of the ram tend to pack the coal so as to necessitate its removal from the ram case.

Fires must be cleaned when the accumulation of noncombustible matter in the furnace interferes with combustion. The greater portion of refuse forms in a clinker on the dead plates. Lift the clinker from the dead plate with a slice bar, Fig. 6, turning it over so that live coals will fall off the top side and remove only the clinker with a hook. Never clean so as to expose the dead plates to the intense heat of the fires, but let the ash and unconsumed coke remain on the side plates. Clean on the dead plates and top of the tuyere blocks only, because the retort will keep itself clean. Always shut off the forced draft, and to not burn the fire down too thin before cleaning.

With the proper stroke of the pusher rod, a constant depth of fire will be maintained throughout the length of the retort, and the body of fuel will have an upward as well as a backward movement. The delivery of coal may be readily increased at the front end of the retort by decreasing the stroke of the pusher rod, and vice versa. To decrease the stroke of the pusher rod, move the midbolt in the pusher-rod straps one or two holes nearer the retort end of the strap, and vice versa.

To bank the fires introduce several charges of coal by means of the ram, then shut off the forced draft and close

the fire-doors and the damper. If the fires are banked for a long period, clinker and coke may form in the retort. The clinker should be removed and the coke broken up before attempting to operate the ram.

If the ram fails to complete the forward stroke, shut off the feed of coal and withdraw the ram by operating the valve with the crank. Also shut off the steam supply to the stoker and place the automatic valve so that both ports are closed, then set the index trigger at zero, let all the steam out of the cylinder and remove the coal from the hopper and ram case until the obstruction is

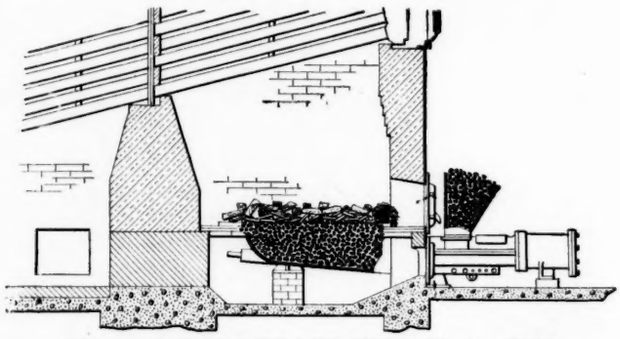


FIG. 5. RETORT FILLED WITH COAL, WOOD AND OILY WASTE ON TOP

found. Never remove coal from the ram case with the hands, but always use a small shovel or a stick, and keep all spikes, scraps of iron, sticks, etc., out of the hopper. Keep the hopper filled with coal and never operate the ram when the hopper is empty. Never slice or bar the fires except at the time of cleaning.

When the stack draft is insufficient to carry the products of combustion to the heating surface of the boilers or when too much forced draft is carried, some gas is likely to back out through the hopper, and this may also be occasioned by carrying the fire too low or by allowing a clinker to remain immediately over the front end of the retort. By carrying the fire approximately as shown in Fig. 2, and by reducing the air supply from the forced-draft fan, the trouble will be overcome unless the stack draft is insufficient, in which event the only remedy is to provide additional draft.

Steam pressure is increased or decreased by increasing or decreasing respectively the forced draft and the supply of coal. This is automatically accomplished in accord-

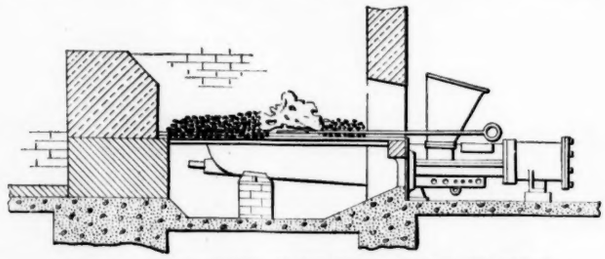


FIG. 6. REMOVING CLINKERS FROM STOKER

ance with the demands for steam. A slight fall in steam pressure gives an increased feed of coal and an increased forced draft. Cleaning the ashpit or air chamber should be done as often as required.

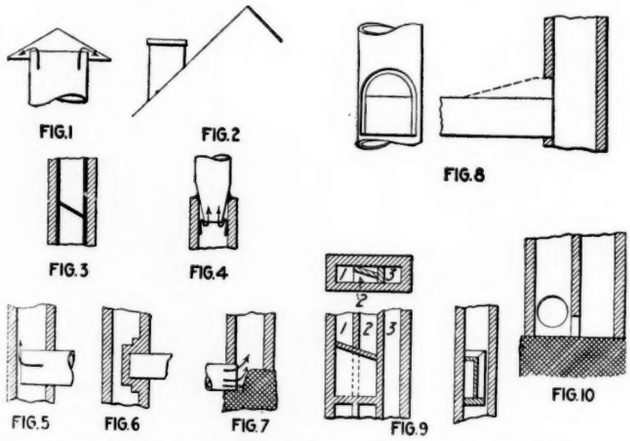
The care of the stoker requires that an examination of the bolts on the pusher-rod connections be made frequently, keeping them in proper condition, oiling the cylinder often and keeping the stuffing-box packed.

# Some Faulty Chimney Designs

By Martin A. Rooney

While there are undoubtedly a large number of chimneys that are improperly designed and the proportions of which are such that it is impossible to secure adequate draft at their base to do the work imposed upon them, there are many chimneys which, although designed properly, do not operate satisfactorily on account of some defect in construction. Figs. 1 to 10 show several such cases that have been met with, and since these defects are sometimes hard to detect on a job that is in operation, these examples may prove of assistance in locating such faults.

Fig. 1 shows a chimney with a cap that has been set too close to the top, thus seriously restricting the draft. Another chimney was constructed in the lee of a high roof gable, Fig. 2. The wind, when blowing over the top of the gable, will seriously interfere with the draft. In Fig. 3 is shown a small chimney lined with fire-clay




FIGS. 1 TO 10. SHOWING DETAILS OF FAULTY CHIMNEY DESIGN

tile. On one side a tile was broken out and fell across the flue in the position shown, forming a shelf for the accumulation of soot and other débris that might fall down the chimney.

The chimney shown in Fig. 4 was extended by adding a steel stack to one made of brick. The base of the steel stack was contracted so as to fit the brick chimney and was made so small that the draft was seriously interfered with. Fig. 5 shows a common mistake. A breeching made too long is shoved so far into the chimney that there is not enough room for the gases to pass from the end of the breeching up the stack.

In Fig. 6 is shown a practice that is reprehensible, not only from the standpoint of draft production, but from that of fire prevention. A wooden joist has been allowed to extend into the stack. Sometimes when a breeching enters a stack near the foundation line, part of the foundation is torn away to allow for the entrance of the smoke pipe. This is frequently done as shown in Fig. 7, thus restricting the passage of the gas.

A condition that the writer has encountered on more than one occasion is shown by Fig. 8. The opening in the chimney to receive the breeching was arched over with brick, and it was intended by the designer that the breeching should be shaped as shown by the dotted lines. Through some error, however, it was made as shown by the full lines, leaving the semicircular space above the

breeching open, the breeching being near the ceiling and the opening hidden by beams and piping. The plant in which this defect was found ran for several weeks before this source of loss was detected.

A condition sometimes found in small apartment buildings and residences is illustrated by Fig. 9. An old chimney containing several flues, each intended to serve a separate fireplace, is sometimes converted into a boiler chimney. The method used of connecting the fireplace to the different flues generally cuts off all of the chimney below the fireplace which is so connected and will form an obstruction in the chimney when an attempt is made to use its entire length.

Fig. 10 shows a boiler connection in a chimney containing two flues with an opening in the partition between them. The hot gases entering one flue will draw cold gas down the other flue and up the one containing the hot gases and on account of lack of draft will make it practically impossible to operate a boiler connected to the stack.

# Visits of Inspector Brown—XXIX

By J. E. Terman

*SYNOPSIS—The Chief tells of diagraming Code formulas on circular flues. These formulas can be adapted to the diagrammatic method of getting at values that would be of use to the inspectors and designers of boilers. He also shows a diagram for a quadruple-riveted joint, by which the efficiency can be obtained direct.*

"Well, Brown, I see that you are back again," said the Chief, as he looked up and found Brown standing at the other side of the table he used for a desk.

"Sure Chief, you said that you would show me how some other formulas could be diagramed, and I want all the information that you will give me on the subject."

"I have just made some experiments on the diagraming of the Code formulas on circular flues," said the Chief, "and they seem to be well adapted to the diagrammatic method of getting at the values that the inspector or designer of boilers wants. Here are the formulas:

$$P = \frac{10{,}000{,}000\,T^3}{D^3} \qquad (1)$$

where the value of $T$ is less than $0.023\,D$, and

$$P = \frac{17{,}300\,T}{D} - 275 \qquad (2)$$

where the value of $T$ is more than $0.023D$. In these formulas

"$P$ = Maximum allowable working pressure in pounds per square inch;

"$T$ = Thickness of the flue in inches;

"$D$ = Outside diameter of the flue in inches."

"What do you do, Chief, when $T$ is exactly equal to $0.023D$?" asked Brown.

"The Code does not cover that exact case," answered the Chief. "We will discuss that later, but it is not a matter of importance.

"The first thing to look after," continued the Chief, "is to see if both of these formulas could be represented by straight lines on the same diagram."

"It looks to me, Chief, as if that would be no trouble at all, for if $D$ is considered to have a constant value in both formulas there would be just two variables left to be dealt with in each and both formulas would be straight-line formulas," said Brown. "Hold on, Chief," exclaimed Brown, before the Chief could take him up, "I want to take that back. I can see that the values of $T$ for formula (1) would have to be laid off as cubes of that variable in order to have straight lines represent the different values of $D$. In formula (2) the values of $T$ would have to be laid off as direct values of that variable in order to represent the different values of $D$ by straight lines. Therefore, the two formulas could not be represented by straight lines on the same diagram in this manner."

"Since you corrected yourself so promptly on that mistake, you had better try the solution of this problem over again," said the Chief.

After a little thought, Brown said: "I can see that the easy way to arrange formula (1) for diagraming is to take the cube root of each side and write it this way,

$$\sqrt[3]{P} = \frac{\sqrt[3]{10{,}000{,}000}\,T}{D}$$

which will be the same as

$$D = \frac{215.4}{\sqrt[3]{P}}\,T \qquad (3)$$

"That's right, Brown; don't you see how you can arrange formula (2) to express the value of $D$?"

"Why, here it is. I did not realize that it would come out like that," said Brown, writing

$$D = \frac{17{,}300}{P + 275}\,T \qquad (4)$$

"You can see from formulas (3) and (4) that there should be no trouble in representing them by straight lines, where each line represents a value of $P$ and the variable values of $D$ and $T$ are to be laid off on the coordinate axes," said the Chief. "Now, how are you to tell in what part of the diagram the lines representing each formula are to apply?"

"Well, it is easy to see from formulas (1) and (2) that, if the values of $T$ are expressed in terms of $D$, the result in each case will be a numerical value for $P$, for the variables on the right-hand side of the equation in this case will cancel out," said Brown. "I haven't tried it, Chief, but I suppose that both formulas will give the same value for $P$, where $T = 0.023D$."

"As I told you a few moments ago, Brown, the Code does not provide for the case where $T$ becomes just equal to $0.023D$. We will try to find the value of $P$ where the value of $T$ is assumed to be $0.023D$, by substituting this value in each formula. Substituting $0.023D$ for $T$ in formula (1), the result is 121.67 lb. as a value for $P$, while performing the same operation in the case of formula (2) gives a value of 122.9 lb. for $P$. This means that the two formulas do not cross at exactly the same point. You know that, if Casey's foreman had a

flue where the thickness was just $0.023D$, he would insist on using the formula that would give him the highest pressure, and I don't know of any reason why you should not let him have it," said the Chief.

"There is another and simple way to secure the dividing line on our diagram to guide us in applying the correct formula, and it avoids considering the exact pressure that may be represented by this line, just as the Code avoids this same question. If the diagram we are talking about is to be drawn on the basis of formulas (3) and (4), the variables will be $T$ and $D$, I believe you said. Well, then," continued the Chief, "in that case the formula $T = 0.023D$ would be a straight line on the same diagram, and this line would pass through the intersection of the $x$ and $y$ axes. Such a line will divide the diagram in two parts; and the correct values to be used as given by formula (1) should lie on one side of this line, and those to be used as given by formula (2) should lie on the other side.

"If formula (1) is to be considered the governing formula where $T = 0.023D$, then this dividing line will represent a pressure of 121.67 lb.; and if formula (2) is to be considered the governing formula for this particular relation between the thickness and diameter, this dividing line will represent a pressure of 122.9 lb. You don't need to worry at all about this matter, Brown, for the differences are too small to be of importance. In making our diagram (Fig. 1) we will draw dotted the line $T = 0.023D$, so as to distinguish it from the other lines representing pressures. The next thing to be decided is the increments in pressure to be used in making our diagram. While you may want to make a diagram with closer divisions for pressure, to illustrate how such a diagram may be made, 10-lb. increases can be used," said the Chief.

"You will notice that the Code limits the size of flues to which formulas (1) and (2) are applicable, the minimum diameter being 5 in. and the maximum 18 in., so we will arrange our scale of diameters to suit this range. The thicknesses will be arranged to progress by thirty-seconds of an inch. The horizontal lines representing diameters will be arranged in 1-in. increments, although if you make a diagram, you will probably want to indicate differences of $\frac{1}{2}$ in. in diameters. It can be seen from formulas (3) and (4) that, where $P$ is considered constant for each line of the diagram, all the lines will pass through the intersection of the coördinate axes, for both of the formulas under these conditions are of the form $y = ax$.

"Since decreases in thickness must of necessity weaken a flue, the lines on our diagram, representing pressures, which lie to the left of the dotted line $T = 0.023D$, must be obtained from formula (3), and those to the right of this line should be obtained from formula (4). Since all the lines of the diagram will pass through the intersection of the coördinate axes, it is only necessary to secure one point on each in order to produce it. A further short-cut may be taken advantage of in drawing the lines to represent formula (4), by noting that equal increases in values of $P$ will result in equal in-

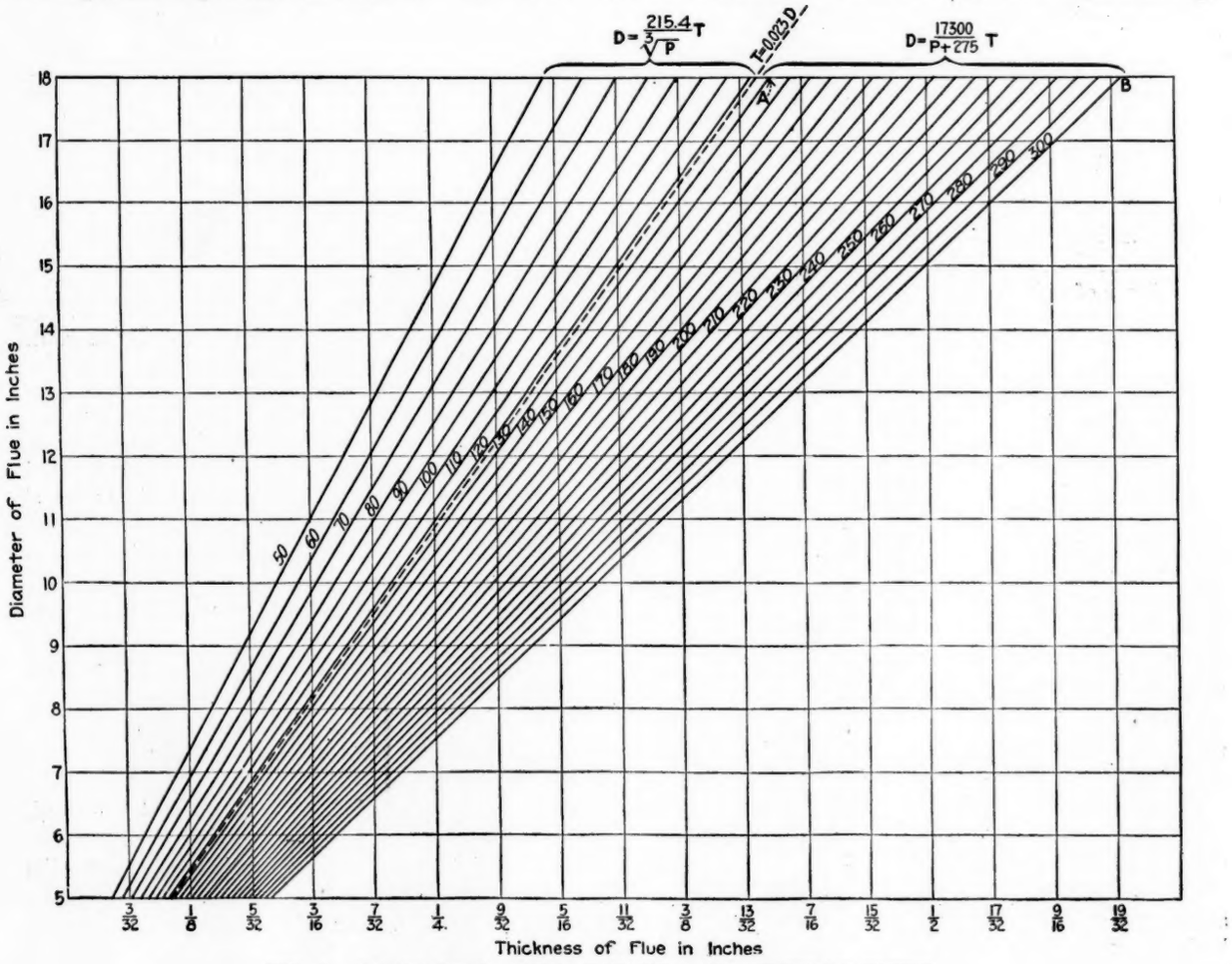



FIG. 1. DIAGRAM OF CODE FORMULA ON CIRCULAR FLUES

creases in the values of $D$; that is, on any horizontal line the distances between the lines representing 10-lb. increases in $P$ will be equal.

"Therefore, it is only necessary to obtain the points on a horizontal line to represent the highest value for $P$ to be considered and the lowest value to an even 10 lb. where formula (4) is applicable, and divide the distance between these points into even divisions, one greater in number than the intermediate values of $P$ to be considered. For example, on this diagram (Fig. 1) I have found the location of points $A$ and $B$ on the 18-in. diameter line for pressures of 130 and 300 lb. Between these two pressures there are 16 intermediate pressures to be considered if 10-lb. increases are to be used; therefore, the distance between these two points has been divided into 17 equal spaces. These points thus obtained represent the intersection of the other pressure lines of the diagram with the 18-in. line. Of course, the points of intersection for the lines to the left of the dotted line $T = 0.023D$, representing values as given by formula (3), cannot be obtained in this way, and a point on each of these lines must be calculated.

"All the points found are connected with the intersection of the $x$ and $y$ axes, and the diagram is completed. I have not located the intersection of the axes on this diagram, in order to avoid taking up space that would not be of benefit in the use of the diagram. You can see that the diagrammatic representation of the Code formulas giving the maximum allowable working pressure for circular flues is a simple problem and at once cares for all the limiting conditions specified for the use of these formulas."

"That is certainly simple, Chief. Why can't you make a diagram that will give the efficiency of riveted joints? I haven't told you, Chief, but I bought a slide rule and have learned to use it; and I have worked myself almost blind trying to get up a complete set of tables that will give me joint efficiencies on the basis of the new Code values for shearing strength of rivets."

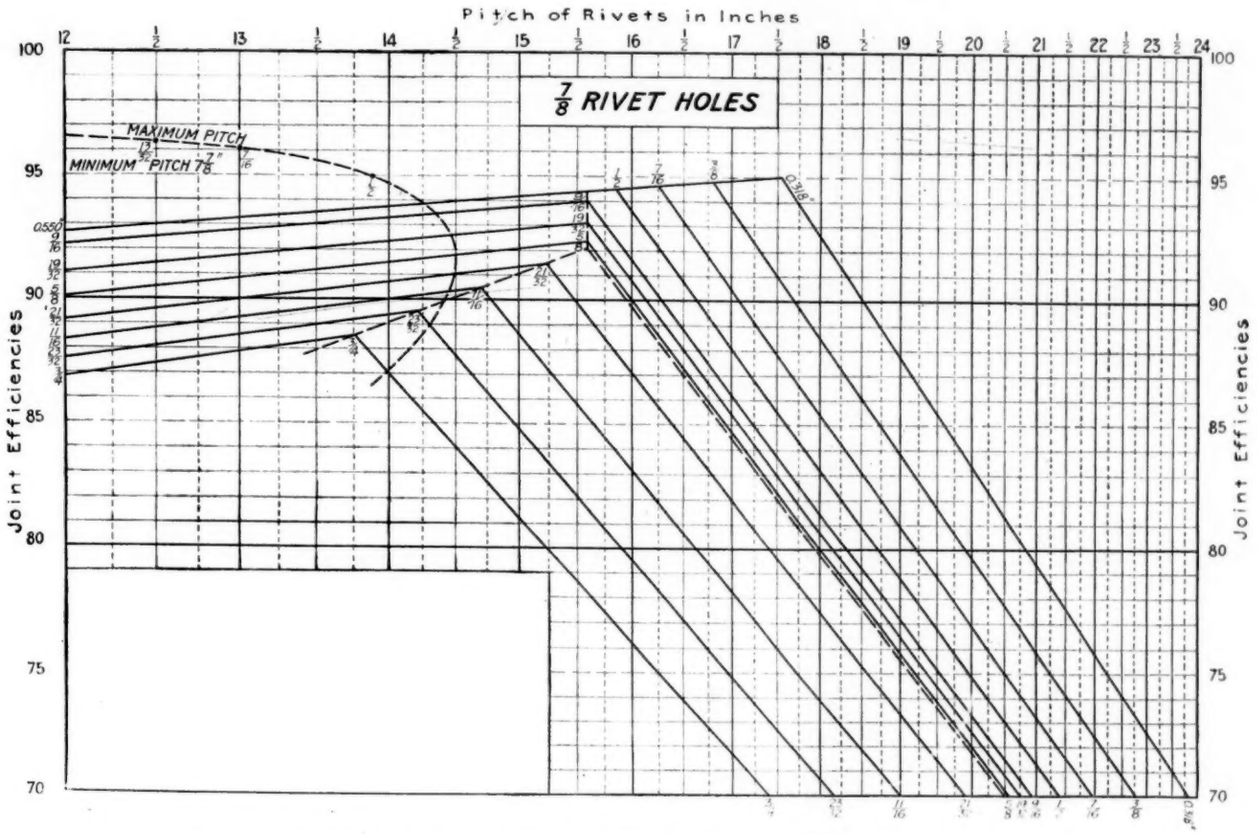



FIG. 2. DIAGRAM FOR QUADRUPLE-RIVETED JOINT USING ⅞-IN. RIVET HOLES

"Well, it is perfectly feasible to make diagrams that will read joint efficiencies direct," said the Chief, "Here is such a diagram for a quadruple-riveted joint using ⅞-in. rivet holes (Fig. 2).[1] To obtain the efficiency of a quadruple-riveted joint with ⅞-in. rivet holes by means of this diagram, you follow down the pitch line until it intersects a line marked for the plate thickness under consideration, and the horizontal line near this intersection will show the joint efficiency. The top line of the diagram from the short vertical dotted line near the center of the diagram to its left-hand extremity represents all plate thicknesses up to 0.55 in., which you will notice is marked at its end. For example, suppose the pitch was 15 in. and the plate thickness $\frac{11}{16}$ in. The intersection of these two lines lies at a point representing an efficiency of about 88½ per cent. and you will find that the efficiency is very near that value, if you will figure it carefully. It is quite a long explanation to show how such diagrams may be made with the least effort; and there is no real need of my explaining the matter to you, for it has been fully explained in book form and you can secure the book, if you want to save your eyes on that slide rule."

[1]Reproduced from "Riveted Boiler Joints," by S. F. Jeter, by permission of the McGraw-Hill Book Co., Inc. The book contains 75 similar diagrams covering all types and designs of boiler joints.

# Safe Pressure for Given Pipes

By John G. Farrar

The accompanying tables, showing the thickness of the walls of special pipes and tubes by the Birmingham wire gage and in decimals of an inch for the given pressures, will no doubt be interesting to *Power* readers and will be of special value to designers and to power-plant engineers operating Diesel engines or other machinery where high pressures are used. In case it becomes necessary to renew a pipe, reference to the table will show what size is best suited for the pressure it is to carry. These tables are filled in for working pressures up to approximately 1000 lb. per sq.in. only, as they were compiled for reference on Diesel engine work, and 1000 lb. per sq.in. or thereabouts is the maximum air pressure to be dealt with. For copper, 2500 lb. per sq.in. and for steel 5000 lb. per sq.in. have been used as the basis of stress. If a lower working stress is desired, the pressure any tube will stand at that stress can be readily determined by multiplying the pressure given in the table by the working stress desired and dividing by 2500 for copper tubes and 500 for steel tubes, or the tube thickness must be increased proportionately.

TABLE 1. STANDARD COPPER TUBES

Thickness of Wall (B.W.G. and Inch Equivalents)

| Outside Dia., In. | 19<br>0.042 | 18<br>0.049 | 17<br>0.058 | 16<br>0.065 | 15<br>0.072 | 14<br>0.083 | 13<br>0.095 | 12<br>0.109 | 11<br>0.120 | 10<br>0.134 | 8<br>0.165 | 7<br>0.180 | 6<br>0.203 | 5<br>0.220 | 4<br>0.238 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ¼ | 0.022<br>1,265 | | | | | | | | | | | | | | |
| ⅜ | 0.041<br>918 | 0.033<br>1,142 | | | | | | | | | | | | | |
| ½ | 0.066<br>722 | 0.060<br>885 | 0.053<br>1,120 | 0.047<br>1,325 | 0.042<br>1,558 | | | | | | | | | | |
| ⅝ | 0.096<br>594 | 0.090<br>722 | 0.081<br>902 | 0.074<br>1,060 | 0.067<br>1,227 | 0.058<br>1,528 | | | | | | | | | |
| ¾ | 0.136<br>505 | 0.127<br>610 | 0.116<br>755 | 0.107<br>880 | 0.099<br>1,010 | 0.088<br>1,242 | | | | | | | | | |
| ⅞ | 0.230<br>388 | 0.218<br>465 | 0.204<br>569 | 0.193<br>657 | 0.182<br>750 | 0.166<br>904 | 0.148<br>1,090 | | | | | | | | |
| 1 | 0.349<br>316 | 0.334<br>375 | 0.315<br>457 | 0.302<br>525 | 0.288<br>595 | 0.268<br>710 | 0.246<br>848 | 0.222<br>1,025 | 0.204<br>1,175 | | | | | | |
| 1⅛ | 0.490<br>266 | 0.474<br>315 | 0.452<br>382 | 0.436<br>436 | 0.419<br>492 | 0.395<br>585 | 0.368<br>693 | 0.339<br>830 | 0.317<br>945 | 0.289<br>1,100 | | | | | |
| 1¼ | 0.659<br>229 | 0.638<br>272 | 0.613<br>328 | 0.594<br>374 | 0.576<br>420 | 0.560<br>498 | 0.515<br>586 | 0.480<br>700 | 0.454<br>790 | 0.422<br>915 | 0.352<br>1,230 | | | | |
| 1⅜ | 0.849<br>201 | 0.826<br>239 | 0.801<br>288 | 0.778<br>327 | 0.756<br>367 | 0.722<br>433 | 0.687<br>508 | 0.646<br>600 | 0.617<br>678 | 0.578<br>783 | 0.495<br>1,037 | 0.458<br>1,175 | | | |
| 1½ | 1.065<br>180 | 1.045<br>214 | 1.010<br>256 | 0.985<br>290 | 0.960<br>326 | 0.925<br>383 | 0.885<br>450 | 0.838<br>528 | 0.802<br>595 | 0.758<br>682 | 0.662<br>897 | 0.512<br>1,110 | 0.560<br>1,200 | 0.515<br>1,360 | |
| 1⅝ | 1.570<br>148 | 1.545<br>175 | 1.505<br>210 | 1.475<br>238 | 1.445<br>266 | 1.405<br>310 | 1.350<br>363 | 1.290<br>425 | 1.245<br>476 | 1.190<br>544 | 1.07<br>705 | 1.02<br>789 | 0.940<br>927 | 0.883<br>1,040 | 0.825<br>1,162 |
| 1¾ | 2.175<br>126 | 2.140<br>148 | 2.100<br>177 | 2.060<br>201 | 2.025<br>224 | 1.970<br>262 | 1.910<br>305 | 1.845<br>356 | 1.790<br>398 | 1.725<br>452 | 1.58<br>581 | 1.51<br>647 | 1.420<br>755 | 1.348<br>840 | 1.27<br>935 |
| 2 | 2.88<br>110 | 2.84<br>129 | 2.79<br>154 | 2.74<br>174 | 2.70<br>194 | 2.64<br>226 | 2.57<br>263 | 2.49<br>306 | 2.43<br>341 | 2.35<br>387 | 2.18<br>493 | 2.11<br>548 | 2.00<br>636 | 1.91<br>706 | 1.82<br>782 |
| 2¼ | 3.68<br>97 | 3.64<br>230 | 3.57<br>136 | 3.53<br>153 | 3.48<br>171 | 3.41<br>199 | 3.33<br>230 | 3.24<br>268 | 3.17<br>298 | 3.09<br>338 | 2.89<br>429 | 2.80<br>476 | 2.68<br>550 | 2.57<br>607 | 2.47<br>672 |
| 2½ | 4.59<br>87 | 4.53<br>102 | 4.46<br>122 | 4.41<br>137 | 4.35<br>153 | 4.27<br>178 | 4.18<br>206 | 4.10<br>238 | 4.01<br>265 | 3.91<br>300 | 3.69<br>380 | 3.60<br>420 | 3.44<br>485 | 3.33<br>534 | 3.21<br>588 |
| 2¾ | 5.58<br>79 | 5.52<br>93 | 5.44<br>110 | 5.38<br>124 | 5.33<br>138 | 5.25<br>160 | 5.15<br>185 | 5.03<br>215 | 4.94<br>239 | 4.85<br>270 | 4.60<br>341 | 4.48<br>376 | 4.33<br>432 | 4.19<br>476 | 4.06<br>523 |
| 3 | 6.67<br>72 | 6.61<br>84 | 6.53<br>101 | 6.46<br>114 | 6.40<br>126 | 6.30<br>147 | 6.20<br>169 | 6.08<br>196 | 5.98<br>217 | 5.87<br>245 | 5.59<br>309 | 5.37<br>341 | 5.28<br>392 | 5.15<br>430 | 5.00<br>471 |

Upper numbers denote inside cross-sectional area in square inches; lower numbers denote pressures required to stress tubes to 2,500 lb. per sq.in.

TABLE 2. STANDARD STEEL TUBES

Thickness of Wall (B.W.G. and Inch Equivalents)

| Outside Diam., In. | 19<br>0.042 | 18<br>0.049 | 17<br>0.058 | 16<br>0.065 | 15<br>0.072 | 14<br>0.083 | 13<br>0.095 | 12<br>0.109 | 11<br>0.120 | 10<br>0.134 | 1/8*<br>0.156 | 3/16*<br>0.187 | 1/4*<br>0.219 | 5/16*<br>0.250 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ¼ | 0.136<br>1,010 | 1,220 | | | | | | | | | | | | |
| ⅜ | 0.230<br>776 | 0.218<br>930 | 0.204<br>1,138 | | | | | | | | | | | |
| ½ | 0.349<br>632 | 0.334<br>751 | 0.315<br>914 | 0.302<br>1,050 | 1,190 | | | | | | | | | |
| ⅝ | 0.490<br>532 | 0.474<br>630 | 0.452<br>764 | 0.436<br>873 | 0.419<br>984 | 0.395<br>1,170 | | | | | | | | |
| ¾ | 0.659<br>458 | 0.638<br>544 | 0.611<br>656 | 0.594<br>748 | 0.574<br>840 | 0.545<br>996 | 0.515<br>1,170 | | | | | | | |
| ⅞ | 0.849<br>403 | 0.826<br>478 | 0.800<br>576 | 0.778<br>654 | 0.756<br>734 | 0.722<br>866 | 0.687<br>1,016 | 0.646<br>1,200 | | | | | | |
| 1 | 1.065<br>360 | 1.045<br>428 | 1.010<br>512 | 0.985<br>580 | 0.960<br>652 | 0.925<br>766 | 0.885<br>900 | 0.838<br>1,056 | 0.802<br>1,190 | | | | | |
| 1⅛ | 1.570<br>296 | 1.545<br>350 | 1.505<br>420 | 1.475<br>476 | 1.445<br>532 | 1.405<br>620 | 1.350<br>726 | 1.290<br>850 | 1.245<br>952 | 1.190<br>1,088 | | | | |
| 1¼ | 2.175<br>252 | 2.140<br>296 | 2.100<br>354 | 2.060<br>402 | 2.025<br>448 | 1.970<br>524 | 1.910<br>610 | 1.845<br>712 | 1.790<br>796 | 1.725<br>904 | 1.625<br>1,084 | | | |
| 1⅜ | 2.88<br>220 | 2.84<br>258 | 2.79<br>308 | 2.74<br>348 | 2.70<br>388 | 2.64<br>452 | 2.57<br>526 | 2.49<br>612 | 2.43<br>682 | 2.35<br>773 | 2.24<br>924 | 2.07<br>1,150 | | |
| 1½ | 3.68<br>194 | 3.64<br>228 | 3.57<br>272 | 3.53<br>306 | 3.48<br>342 | 3.41<br>398 | 3.33<br>460 | 3.24<br>536 | 3.17<br>596 | 3.09<br>676 | 2.95<br>804 | 2.76<br>996 | 2.58<br>1,205 | |
| 1⅝ | 4.59<br>174 | 4.53<br>204 | 4.46<br>244 | 4.41<br>274 | 4.35<br>306 | 4.27<br>356 | 4.18<br>412 | 4.10<br>476 | 4.01<br>530 | 3.91<br>600 | 3.76<br>712 | 3.55<br>878 | 3.34<br>1,060 | 3.14<br>1,250 |
| 1¾ | 5.58<br>158 | 5.52<br>186 | 5.44<br>220 | 5.38<br>248 | 5.33<br>276 | 5.25<br>320 | 5.15<br>370 | 5.03<br>430 | 4.94<br>476 | 4.85<br>540 | 4.66<br>640 | 4.43<br>788 | 4.19<br>947 | 3.98<br>1,110 |
| 2 | 6.67<br>144 | 6.61<br>168 | 6.53<br>201 | 6.46<br>228 | 6.40<br>252 | 6.30<br>294 | 6.20<br>338 | 6.08<br>392 | 5.98<br>434 | 5.87<br>491 | 5.68<br>580 | 5.41<br>712 | 5.15<br>855 | 4.91<br>1,000 |

* Thickness of tubes are listed by the manufacturers in fractions of an inch—not by gage numbers for these sizes.
Upper numbers denote inside cross-sectional area in square inches; lower numbers denote pressures required to stress tubes to 5,000 lb. per sq.in.

# The Electrical Study Course—Series- and Parallel-Circuit Calculations

*SYNOPSIS—Problems involving parallel and series circuits are worked out and explained by hydraulic analogies.*

The study problems given in the lesson on parallel circuits are shown in Figs. 1, 3 and 5. In the first problem, Fig. 1, $I_1 = \frac{E}{R_1} = \frac{360}{9} = 40$ amperes; $I_2 = \frac{E}{R_2} = \frac{360}{15} = 24$ amperes; and $I_3 = \frac{E}{R_3} = \frac{360}{20} = 18$ amperes; $I = I_1 + I_2 + I_3 = 40 + 24 + 18 = 82$ amperes. The joint resistance $R$ of the circuit by Ohm's law is $R = \frac{E}{I} = \frac{360}{82} = 4.39$ ohms. By the joint resistance formula,

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{1}{9} + \frac{1}{15} + \frac{1}{20}} = \frac{1}{\frac{41}{180}} = \frac{180}{41}$$

$$= 4.39 \text{ ohms}$$

the same as by the Ohm's law method. Ammeter $B$ will read the current flowing in the branch of the circuit that it is connected in, that is, the current flowing through $R_1$, or 40 amperes; ammeter $C$ will read 24 amperes, the current passing through $R_2$; ammeter $D$ will read 18 amperes, the current flowing in $R_3$; and ammeter $A$ will read the total current flowing in the circuit—the sum of the readings of $B$, $C$ and $D$, or 82 amperes.

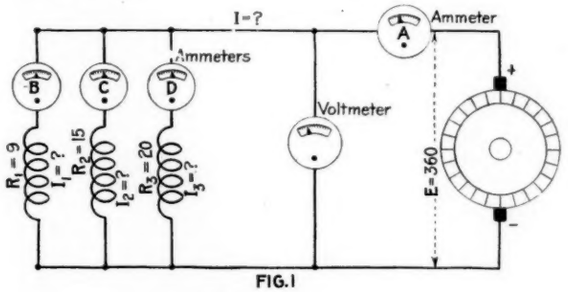


FIG. 1

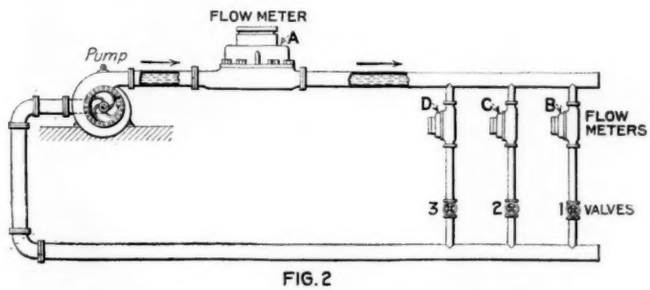


FIG. 2

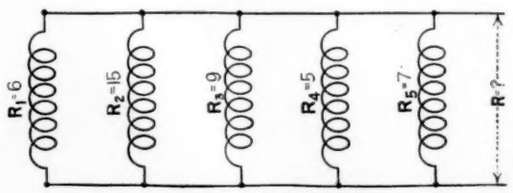


FIG. 3

The conditions in the problem, Fig. 1, are represented by the hydraulic analogy, Fig. 2, where a pump is shown with its discharge and intake connected together in a pipe system. The three branch circuits, 1, 2 and 3, Fig. 2, represent respectively $R_1$, $R_2$ and $R_3$, Fig. 1. The flow meters $A$, $B$, $C$ and $D$ in the latter represent respectively the ammeters $A$, $B$, $C$ and $D$ in the former. If the pipe system is full of water and the pump driven, meter $B$ will read the quantity of fluid flowing through circuit No. 1, $C$ that flowing through No. 2, $D$ that passing through No. 3 and $A$ the total indicated by $B$, $C$ and $D$, the same as ammeter $A$ reads the total current passing through ammeters $B$, $C$ and $D$, Fig. 1.

There can be no mistaking what an ammeter should read if the circuit is traced from the positive terminal around to the negative. In Fig. 1, starting from the positive terminal and tracing the circuit through $R_1$ we find that the current passes through ammeters $A$ and $B$, but does not go through $D$ or $C$. Likewise, in following the circuit through $R_2$ the current in this circuit passes through ammeters $A$ and $C$, but not through $B$ and $D$. That through $R_3$ passes through ammeters $A$ and $D$, but not through $B$ and $C$. In each case the current of only one circuit passes through ammeters $B$, $C$ and $D$, where the current of all three circuits passes through ammeter $A$. Consequently ammeters $B$, $C$ and $D$ will read only the current of the individual circuits that they are connected in, and ammeter $A$ reads the total of the three.

The second study problem is given in Fig. 3. By the joint-resistance formula,

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}} = \frac{1}{\frac{1}{6} + \frac{1}{15} + \frac{1}{9} + \frac{1}{5} + \frac{1}{7}}$$

$$= \frac{1}{\frac{433}{630}} = \frac{630}{433} = 1.45 \text{ ohms}$$

In the last lesson it was pointed out that in a simple parallel circuit, like that shown in the figure, the joint

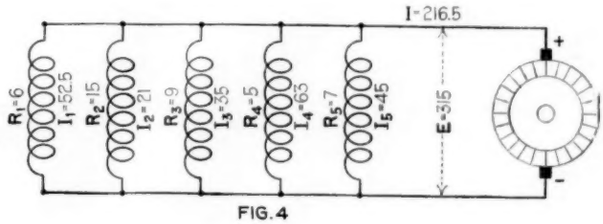


FIG. 4

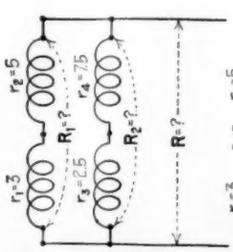


FIG. 5

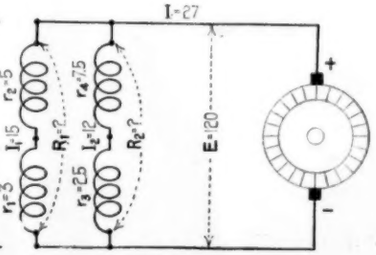


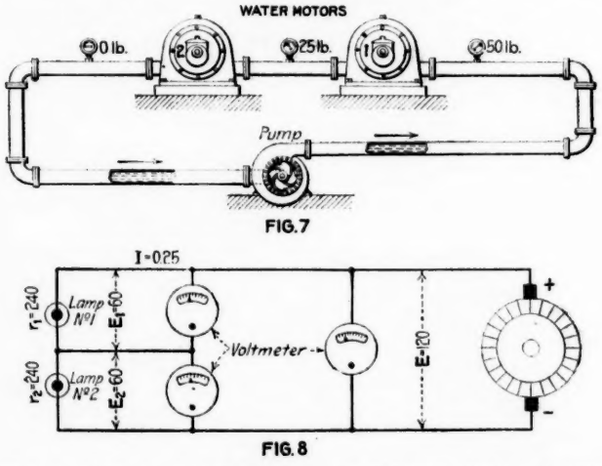
FIG. 6

FIGS. 1 TO 6. REPRESENT SERIES AND PARALLEL CIRCUITS

resistance could always be found by assuming some convenient voltage applied to the circuit and then applying Ohm's law. In this case assume that the voltage $E$ equals 315, as indicated in Fig. 4. Then $I_1 = \frac{E}{R_1} = \frac{315}{6} = 52.5$ amperes; $I_2 = \frac{E}{R_2} = \frac{315}{15} = 21$ amperes; $I_3 = \frac{E}{R_3} = \frac{315}{9} = 35$ amperes; $I_4 = \frac{E}{R_4} = \frac{315}{5} = 63$ amperes; and $I_5 = \frac{E}{R_5} = \frac{315}{7} = 45$ amperes. The total current $I$ equals the sum of the currents in the individual circuits, or $I = I_1 + I_2 + I_3 + I_4 + I_5 = 52.5 + 21 + 35 + 63 + 45 = 216.5$ amperes.

By Ohm's law the joint resistance is $R = \frac{E}{I} = \frac{315}{216.5} = 1.45$ ohms. This checks up with the result obtained by the joint-resistance formula.

The third problem given in the last lesson is shown in Fig. 5. In this problem we have two circuits in parallel, each circuit made up of two resistances in series; that is, $r_1$ and $r_2$ are connected in series forming the circuit $R_1$,




FIGS. 7 AND 8. ILLUSTRATE PRESSURE DROP ALONG A CIRCUIT

and $r_3$ and $r_4$ are connected in series forming the circuit $R_2$. The first thing to do in this problem is to find the resistance of each individual circuit. We found out in a previous lesson that the total resistance of a circuit composed of two or more resistances connected in series is equal to the sum of the individual resistances so connected. Hence $R_1 = r_1 + r_2 = 3 + 5 = 8$ ohms, and $R_2 = r_3 + r_4 = 2.5 + 7.5 = 10$ ohms. The joint resistance $R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{8} + \frac{1}{10}} = \frac{1}{\frac{18}{80}} = \frac{80}{18} = 4.44$ ohms.

In this case the joint resistance may also be found by Ohm's law as in the other problems. Assume that $E = 120$, as shown in Fig. 6. Then $I_1 = \frac{E}{R_1} = \frac{120}{8} = 15$ amperes, and $I_2 = \frac{E}{R_2} = \frac{120}{10} = 12$ amperes. The total current $I = I_1 + I_2 = 15 + 12 = 27$ amperes, and the joint resistance is $R = \frac{E}{I} = \frac{120}{27} = 4.44$ ohms, the same as the value obtained in the foregoing.

The following is a question that was received from a reader and is pertinent to these lessons: What would be the voltage after passing through a bank of lamps connected in series? The lamps take 0.5 ampere on a 120-volt circuits.

In answer to this question it might be said that voltage does not pass through lamps or anything else, but is used up in causing a current to flow through the circuit. In Fig. 7 are shown two water motors connected in series in a pipe system assumed to be filled with water, with a pump to cause the fluid to flow. If the pump is driven, it will create a certain difference in the pressure between its discharge and intake, which will cause the water to circulate and drive the motors. As pointed out in a previous lesson, if both motors are the same size, half of the pressure will be used up in causing the water to flow through motor No. 1 and half used up in motor No. 2. Or, theoretically, if we had 50 lb. pressure at the intake of motor No. 1, the pressure would be only 25 lb. at the intake of motor No. 2 and 0 at its discharge, as shown.

Referring to Fig. 8 and assuming that we have two such lamps as mentioned in the question connected in series across a 120-volt circuit, these lamps take 0.5 ampere on a 120-volt circuit, therefore the resistance of each lamp, by Ohm's law is $r = \frac{E}{I} = \frac{120}{0.5} = 240$ ohms, as indicated on the figure. The total resistance of the cir-

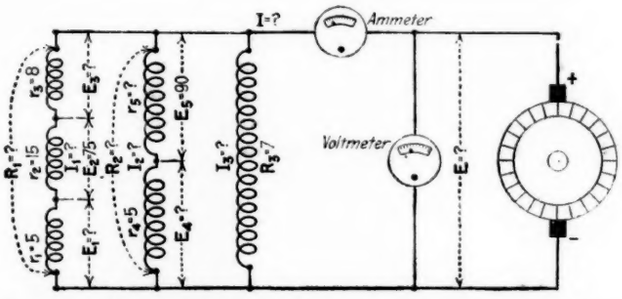



FIG. 9. SHOWS RESISTANCES CONNECTED IN SERIES AND THE CIRCUITS IN PARALLEL

cuit would be the sum of the resistance of the two lamps, or $240 + 240 = 480$ ohms. The current flowing through the two lamps connected in series is $I = \frac{E}{R} = \frac{120}{480} = 0.25$ ampere. In this calculation we find out why two lamps will burn dim when connected in series across a circuit having a voltage equal to the rated volts of one lamp. On the 120-volt circuit one lamp would take $I = \frac{E}{r} = \frac{120}{240} = 0.5$ ampere, as mentioned in the question. But when the two lamps are connected in series, the resistance of the circuit is double and the current is only one-half that taken by one alone, or in this case 0.25 ampere.

There is assumed to be 0.25 ampere flowing from the positive terminal, through the two lamps in series and back to the negative side of the line, just as a certain quantity of water was assumed to be flowing from the discharge of the pump in Fig. 7, through the two motors in series and back into the intake of the pump. In the lamp circuit it was not voltage that passed through the circuit any more than it was pressure, pounds per square

inch, that passed through the pipe system. In each condition the pressure was only a medium that caused a quantity to flow through a given path. Through the pipe system we call this quantity water and through the lamp circuit electricity.

The volt drop across each lamp equals the resistance times the current, or $E_1 = r_1 I = 240 \times 0.25 = 60$ volts, likewise $E_2 = r_2 I = 240 \times 0.25 = 60$ volts; that is, 60 volts of the pressure is used up in causing the current to flow through lamp No. 1 and 60 volts in lamp No. 2, the pressure being all expended by the time the current reaches the negative terminal of No. 2, just as the pressure was all expended by the time the current of water reached the discharge of motor No. 2, Fig. 7. Hence it is seen that pressure is something that does not flow, but is used up in causing something else to be transmitted from one position to another.

In Fig. 9 is given the study problem. In addition to finding the values indicated by the interrogation marks, find the joint resistance $R$ and check the answer, also indicate what each instrument should read.

## Racing Ammonia Compressors

By E. W. Miller

Racing of engine-driven ammonia compressors may be due to either engine or compressor trouble. A competent engineer should have no difficulty in locating the cause if it is in the engine, but when the trouble is in the compressor it is not so easily determined at times. In every case it will be found to be produced by some faulty action of the valves. If a suction valve sticks, the machine is practically unloaded for that part of the revolution, as the gas in the cylinder rushes out again through the open valve. The machine in this case will make a lunge at this part of the revolution, and for every revolution the valve sticks open. A sticking discharge valve will have about the same effect, except that the lunging or irregularity of movement will be more violent owing to the discharge pressure backing up into the cylinder.

When the valves stick only intermittently, the problem becomes still more puzzling and will, under certain conditions, produce the most violent racing. Compressor governors are rather sluggish; any large variation in the load will require some little time for readjustment of the speed. If the machine overspeeds, as it will if any of the valves stick open, it will require a few revolutions to bring the speed back to normal through the action of the governor. If, now, when the governor is at the highest point and consequently admitting the minimum quantity of steam to the engine, the sticking valve suddenly lets loose and throws the full load on again, the speed will drop far below normal before the governor finally gets it under control again and brings it up to normal speed. If the valve happens to stick again at the moment the governor is at its lowest point and admitting a large amount of steam to the engine to bring it up to normal speed, the speed may become exceedingly dangerous before it is finally checked by the governor. If the valve happens to stick at the critical moment several times in succession, it may wreck the machine, unless the governor is more sensitive than the average compressor governor. I had an experience of this kind once. I was standing beside the cylinder of the compressor, which was of the horizontal type, when the machine suddenly started to race. I could hear the gas rushing out through the open suction valve, and I could also hear the valve close the moment it let go. This happened several times in succession, and by the time I got to the machine it was in a serious condition.

Many engineers get busy with the indicator as soon as anything like this happens. This is hardly worth while if a little judgment is used, and it takes too much time. If a discharge valve sticks, the discharge header and the valve on this end will get hotter than on the other end, because the gas that is discharged from the end that is working properly will rush into the end with the sticking valve, and as there is no new gas taken in, it will heat this end. In a short time the frost will also come off the suction valve on this end. If the suction valve sticks, the frost will come off the valve and the discharge will get cold on this end, as there is no gas passing out through it.

By remembering this and then using the same reasoning that one would use in locating a defective valve in a water pump, one should have little difficulty in quickly determining the cause of the trouble. For example, if the machine lunges on the forward stroke, it must be either the discharge valve on the head end or the suction valve on the crank end. The temperature of either of these and the frost on the suction valve will soon indicate which one it is. The defective valve can also generally be located by the sound of the gas rushing out through it.

However, if one is in doubt it is usually safer to use the indicator in preference to taking the valves out in a hit-or-miss search.

## An Unusual Experience

By Louis Vozza

During my first year's experience as an engineer I was employed by a small mining concern as shift engineer. My work consisted of running the hoisting engine, caring for the air compressor, ventilating-fan engine and the lighting system, which consisted of a small vertical engine and a belt-driven dynamo. The latter had for some time been giving more or less trouble. The commutator was in bad shape and the engine governor was inoperative, so we ran on the throttle and the lights fluctuated with each change of load and steam pressure. One evening as I was hoisting a trip, the engine stopped and the lights went out.

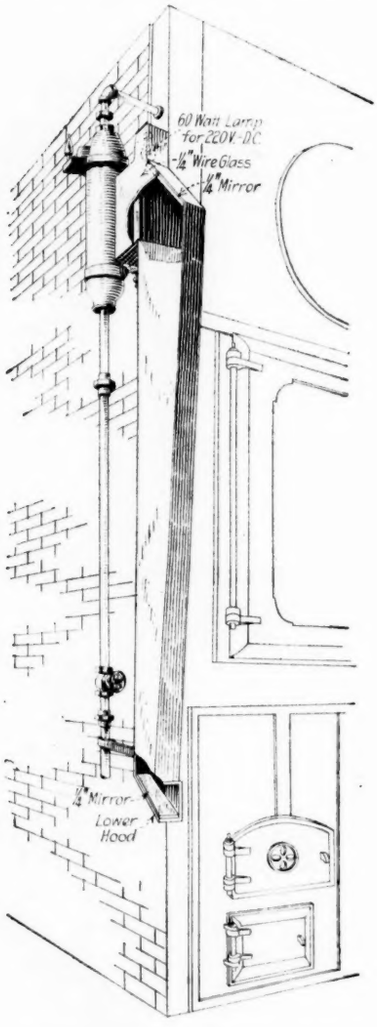
I went to see what had caused the lighting engine to stop, and found the nut holding the valve-stem gland had backed off the stud and in some manner had jammed in between the valve-stem block and the stud, thus causing the engine to stop. I screwed the nut back on the stud and started the engine, but to my surprise the dynamo failed to excite.

I was puzzled as to the cause until I found that the engine had been reversed. The eccentric was held by a setscrew only, and it happened to be slack, and when the valve rod was held stationary, the engine had revolved far enough to reverse the direction of rotation. Setting the eccentric to its former position and tightening the setscrew, I again started the engine. This time the dynamo excited as usual. Doubtless if the eccentric had been keyed rigidly to the shaft the rod would have broken.

## Reiber Gage-Glass Reading Device

In some boiler rooms where the water gage is a considerable distance above the floor, it is difficult for the fireman to see the water level. To meet this condition a reading device has been constructed on the principle of the periscope.

It consists of three parts, the upper and the lower hood and the connecting piece. The upper hood is fastened to the gage valves just above the packing nuts and is recessed for an electric light so placed as to throw its rays directly on the gage-glass, a white enameled slide being placed just back of it giving an added brilliancy.




GAGE-GLASS READING DEVICE

The image is reflected by the mirror in the back of the hood to the lower hood, where the second mirror is placed at an angle to show the image in an upright position in front of the observer and on the level with his eyes. The front of the lower hood is provided with a plate-glass door in order to keep out smoke and dirt and to protect the lower mirror from breakage. The standard design uses two mirrors, but the same results may be obtained with four or even six.

In the event of a steam leak around the packing nuts, the recess for the lamp in the upper hood acts as a ventilator, the heat from the lamp drawing the steam into the recess, where it escapes through openings provided for that purpose. In replacing a gage-glass it is only necessary to remove the sliding glass door in the upper hood, which exposes both packing nuts and makes them readily accessible. The glass door in the top hood also allows one to see the gage in the same manner as at present. The lower end of the device is supported with suitable brackets which take all strain off the gage valves. The device is made from No. 20 gage sheet steel. The mirrors are all $\frac{3}{8}$ in. thick. The glass doors are polished plate $\frac{3}{8}$ in. thick, with $1\frac{1}{4}$ in. wire mesh.

This reading device is manufactured by the Reiber-Gibbs Co., 2516 Smallman St., Pittsburgh, Penn.

## Composition of Commercial Liquid Ammonia

At the last meeting of the American Society of Refrigerating Engineers, E. P. McKelvy and C. A. Taylor, of the Bureau of Standards, Washington, D. C., read a paper on this subject. The full paper appears in the March *"Journal"* of the Society, and relates to the method of testing the various samples of ammonia. The following table is from this paper and shows the composition of 11 different samples of commercial ammonia:

COMPOSITION OF LIQUID ANHYDROUS AMMONIAS

| Sample Marked | Noncondensing Gas | | | | | | | Water | |
|---|---|---|---|---|---|---|---|---|---|
| | Composition | | | | | | | | |
| | In Liquid c.c. per 100 g. | In Gas c.c. per 100 g. | $N_2$, Per Cent. | $O_2$, Per Cent. | $H_2$, Per Cent. | Residue on Evaporation By Weight, Per Cent. | Volatile C Compounds g $CO_2$ per 100 g $NH_3$ | Method KOH, Per Cent. | Method $CaC_2$, Per Cent. |
| A | 7 | | 69.1 | 30.9 | 0.0 | 0.012* | 0.019 | 0.006 | 0.013 |
| | | 26 | 86.7 | 13.3 | 0.0 | 0.007† | | 0.001 | |
| B | 4 | | 70.8 | 29.2 | 0.0 | 0.009* | 0.002 | 0.007 | 0.042 |
| | | 9 | 70.0 | 30.0 | 0.0 | 0.011† | | 0.008 | |
| C | 6 | | 70.3 | 29.7 | 0.0 | 0.008* | 0.051 | 0.007 | 0.030 |
| | | 8 | 69.4 | 30.6 | 0.0 | 0.008† | | 0.005 | |
| D | 6 | | 68.4 | 31.6 | 0.0 | 0.014* | 0.029 | 0.006 | 0.030 |
| | | 12 | 72.6 | 27.4 | 0.0 | 0.017† | | 0.004 | |
| E | 6 | | 65.0 | 35.0 | 0.0 | 0.011* | 0.019 | 0.006 | 0.030 |
| | | 11 | 74.0 | 26.0 | 0.0 | 0.010† | | 0.006 | |
| F | 15 | | 67.0 | 28.7 | 4.0 | 0.015* | 0.061 | ..... | 0.026 |
| | | 8,032 | 80.1 | 19.9 | 0.0 | 0.022† | | | |
| G | 6 | | 70.0 | 27.0 | 3.0 | 0.025* | 0.032 | 0.007 | 0.026 |
| | | 9 | 68.0 | 26.0 | 6.0 | 0.100† | | 0.009 | |
| H | 6 | | 66.7 | 33.3 | 0.0 | 0.062* | 0.902 | 0.010 | 0.027 |
| | | 11 | 66.7 | 33.3 | 0.0 | 0.134† | | 0.010 | |
| K | 7 | | 69.0 | 31.0 | trace | 0.276* | 0.004 | 0.011 | 0.80 |
| | | 19 | 80.0 | 20.0 | trace | 0.300† | | 0.032 | |
| L | 9 | | 77.5 | 22.5 | 0.0 | 0.533* | 0.497 | 0.041 | 0.50 |
| | | 5,680 | 99.4 | 0.6 | trace | 0.540† | | 0.069 | |
| LL | 15 | | 79.0 | 21.0 | 0.0 | 0.318* | 0.103 | 0.053 | 0.33 |
| | | 1,870 | 99.3 | 0.7 | 0.0 | 0.230† | | 0.040 | |
| M | | | | | | 0.040* | 0.014 | | |
| | | | | | | 0.051† | 0.011 | | |
| S | | | | | | 0.000 | 0.000 | | 0.008 |

* Evaporation at room temperature. † Evaporation at low temperature.

**C., M. & St. P. Ry. Co. To Electrify Puget Sound Division**—Engineers under the direction of C. A. Goodnow, of Chicago, assistant to the president of the Chicago, Milwaukee & St. Paul Railway Co., who had charge of the electrification of 440 miles of that company's road between Harlowtown, Mont., and Avery, Idaho, have arrived in Seattle, where headquarters will be established in the Jackson Street Depot of the company preparatory to the starting of work on the electrification of the Puget Sound Division. The first section to be electrified is between Seattle and Othello, and this work will cost $6,000,000. Requisitions for the necessary materials are now in the hands of G. F. Wilder, Western purchasing agent of the company in Seattle, who will place contracts for transmission, trolley and other carrying facilities before June 1. Electric power, which has already been contracted for with the Intermountain Power Co., will be delivered on the east from the Washington Water Power Co.'s plant at Long Lake, 15 miles west of Spokane, on the Spokane River. On the west the current will be brought from the Snoqualmie Falls plant of the Puget Sound Traction, Light and Power Co. The Intermountain Power Co., in order to connect the Long Lake and the Snoqualmie Falls power plants, will be required about 15,000 hp., but as the business of the railroad increases, the contracts for this power will ultimately provide for 25,000 hp. The time of completion has been set for Jan. 1, 1919.

# Editorials

## The Question of Reserve Capacity

The recent hearings before the Massachusetts Board of Gas and Electricity on the question of reserve capacity as installed in the L Street Station of the Edison Electric Illuminating Co. of Boston cannot but create considerable interest in the question: How much reserve capacity should be installed in a power plant?

Obviously the amount depends chiefly upon the money available to spend for it, the kind of service given by the station—whether for private or public consumption—and upon the rapidity of future growth of the demands of the plant. The physical condition of the units installed must, or should, be a factor in determining the spare capacity needed.

The public is rightly interested in how much money a public-utility company has invested in spare equipment, because usually the rates which the consumer must pay for service are influenced unfavorably for him if this investment is more than good engineering judgment would call for. But here is the controversial question. What are the limits of good engineering judgment in this matter? Neither engineers nor the public will consent to be governed by the opinions or practice of one or a few engineers. If public-service commissions are going to regard the Boston case as a precedent, so much the more reason why the question should be widely discussed by the profession. It is the collective opinion that will be valuable. The opinion of any particular individual is inseparable from his idiosyncrasies. Among engineers one man will take a far greater chance than another, and each feels his judgment is most sound.

The influence of the physical condition of the units, especially when each machine is of great capacity, is important. There have been in central stations a disconcerting number of large turbines that have been "lost"; that is disabled by accident to them, during the last year or two. Are we going to learn after long experience with large units that reserve capacity required must be greater if serious service interruptions are to be avoided? For more than a decade engineers have been reducing this reserve capacity. The reduction could with safety be carried much further with small units than seems advisable with the large units of today; and the advantages of the large units are too great to think of going back to the more flexible though less economical small-unit station.

Especially interesting is the recent testimony of L. L. Elden, electrical superintendent of the Edison Electric Illuminating Co. of Boston, regarding the safe overloads on turbines in the L Street Station. The machines mentioned in this respect are of 7500 kw., 12,000 kw., and 15,000 kw. respectively, and not one, he said, could safely carry when clean and in good condition a thousand kilowatts additional load for a period longer than ten minutes. The ability to carry heavy overloads has a marked effect upon the reserve capacity required. Most of the machines to which Mr. Elden referred are quite old, built back in the days when the manufacturer's heart was bigger because his knowledge was smaller. His statement is therefore surprising. We wonder what the builders of these machines think about it.

We should be pleased to receive discussion on this question of reserve capacity.

## Labor's Opportunity

Previous wars were fought largely by the laboring classes. To them not only fell the work of doing the actual fighting, but they were also heavily taxed to pay the expense of actually carrying on the struggle, the capitalists and captains of industry to a large extent considering their country's difficulties an opportunity to advance their own selfish interests.

What may be said of the man of influence and position of the past cannot be said in this crisis; today we find him taking the position of first rank in the Government service. Engineers of every class, who are capable of commanding high salaries in the employ of private corporations, are proffering their service gratis and working for the Government without compensation. The leading men of public utility corporations and industries of almost every kind have come forward and offered their services to the Government to assist in meeting the problems of this great crisis. Consequently, today the Government has at its command the greatest force of engineering and industrial talent that any country has ever been able to boast of in the history of the world. Not alone have these leaders responded, but the industries themselves have shown that they are willing to do their part. No better example of this can be had than that of the steel and copper corporations, who have offered to supply the Government with these materials at extremely low prices. The tentative tax rates indicate that the financial burden is also going to fall upon, and justly so, those with the large incomes. Not only corporations' profits, but also private incomes are to be heavily taxed and excess profits in part requisitioned.

One of the great problems, in fact the most momentous, is that of labor. According to estimates, this country is lacking six million men with no prospect of relieving the situation; on the contrary, there is the prospect of conditions becoming more acute with vast numbers enlisting in the army and navy and the increased demand upon the industries to supply the needs of the war machine. No doubt many of the places made vacant by the men who go to the front will be supplied by women, but there are many positions that can be filled only by skilled male labor. This is the opportunity for the responsible heads of labor organizations to assist in solving this great problem.

We do not wish to advocate longer hours of labor and firmly believe that the eight-hour day is long enough for any man or woman to work in ordinary times. But these are times when things are being done on a scale never dreamed of before in the history of the world. These are

the times when millions of men on the great battle fronts are risking and sacrificing their lives in the defense of the principles of liberty, justice and civilization. These men know no eight-hour a day statute—the only law that is recognized by them is, "Get the task done." In the light of these facts it would seem to be no more than fitting for those who are in the great industries to see to it that the boys in the trenches lack for nothing that it is possible for labor to supply. If there is insufficient labor to furnish these supplies by working eight hours per day, then why not ten or twelve? Even then the task will be much lighter than for those who are risking their lives at the front. In the offices of the various engineering industries there are thousands of men that have seen service as skilled mechanics, electricians, etc., who are going to volunteer for such services to the various industries supplying war materials, to assist in meeting the shortage of skilled labor.

One of the questions that arise when consideration is given to recruiting skilled labor from the sources mentioned is, What attitude are the labor leaders and organizations going to take toward such men? Men who put the interest of their country before every other consideration, who are willing to give up positions that they have worked years to attain, in order that they may serve their Government in time of need—when these men offer their services to the industries, are the labor unions going to take the position which they may be justified in doing in normal times? Are they going to say, "Where is your union card; without it you cannot serve your country in this industry?"

It is to be hoped that the labor organizations in this country will profit by the mistakes of the labor interests as witnessed in England the first year of the war and not put selfish interests before the needs of the country and the needs of the men in the trenches, who were during the first year of the war practically defending themselves with their naked hands. Since our declaration of war the soldiers in the trenches defending the battle fronts of our allies are no longer English, French, etc., but our soldiers; if not in nationality, they are in purpose. Therefore it is our duty to see that they are equipped with everything that is necessary to make them as efficient as possible.

⁂

## Correlating Power and Heating

When a plant can utilize exhaust steam for heating under partial vacuum and operate the power load condensing the year around, the public-service corporation, with its overhead and line losses, will find successful competition much more difficult, when any considerable quantity of power is involved. In fact, hot-water heating using steam from the power load under partial vacuum may be the salvation of many an isolated plant. With the high cost of fuel—usually higher for the small user—competition for the small noncondensing power plant operated in conjunction with steam heating is often close, so that any advantage that will offset the gains in economy constantly being made in the large central station should be welcome. The leading article of this issue and a second to follow analyze the question and show that by properly correlating the power and heating, a gain of 25 per cent. over results in the average plant is possible.

There are office buildings in New York City having an hourly load running from five hundred to two thousand kilowatts. All are operated noncondensing at a minimum of forty-five pounds of steam per kilowatt-hour at the switchboard, when they could be operated under vacuum, with the heating system as a condenser, reducing the steam rate for power throughout the year by a wide margin.

One notable instance in which this plan was effected is the Hoboken terminal of the Delaware & Lackawanna Railroad, which has 100,000 square feet of hot-water heating surface. The plant operates condensing the year around, twenty-eight inches in summer and an average of twenty inches in winter when the heating system takes the place of part of the condensing equipment and permits operation under the most favorable conditions.

The principle of utilizing the cooling effect of the heating system is applicable to any plant where large power and heating units are involved. According to the author of the articles, it can be applied to high buildings or industrial plants with equal facility. Here is a condenser at hand ready made and absolutely required in the form of a heating system. Why not use it?

⁂

New York State needs ten thousand men to bring the National Guard up to war strength. Col. Charles H. Sherrill, who organized the preparedness parade last year, has been charged by Governor Whitman with the task of the recruiting and has enlisted the aid of the Technical and Trade Press. The number of men needed has been proportioned among the various industries, the engineers' quota being one hundred. Single men from 18 to 40 will be taken, which gives an opportunity for many who by age will be debarred from service under the conscription. Moreover, it affords the advantage of choosing the branch of the service. Applications and further information may be had from Roger W. Allen, 30 Broad St., New York.

⁂

A correspondent suggests that the latent talents of our readers be utilized for the public good by inviting discussion in *Power* of means for combating the submarine menace. While commending the spirit of the suggestion, we would caution that the effectiveness of any meritorious scheme might be defeated by such public discussion and would advise further that there is a body, the Naval Consulting Board, at Washington, D. C., regularly constituted to receive such suggestions.

⁂

The series of articles by J. E. Terman, "Visits of Inspector Brown," is of interest to a much wider circle than that of the boiler inspectors. Besides clearing up many of the mooted questions with regard to boiler design it is the best simple explanation of the process of diagraming that we know of. One with a smattering of mathematics and a little patience can by following the Chief's explanations learn to translate many formulas into diagrams with a large measure of interest and profit.

⁂

So far it looks as though the advocates of the low value had the better of the argument as to the amount of energy stored in a boiler under pressure and capable of doing harm when the boiler explodes. We shall publish in an early issue a table computed upon this basis.

# Correspondence

## Feed-Line Valve Was Closed

The letter by Mr. Binns in the issue of Mar. 27, relating to trouble caused by a closed valve in the feed-water line, reminds me of a similar incident in a small plant having two duplex feed pumps connected to the same feed line, the pumps being used alternately.

As the engineer was passing the pump pit one day, he noticed water coming from under the cover of the grease extractor. The feed pump was working very slowly, and the gage on the discharge line stood at zero but on the wrong side of the pin. To make matters worse, the fireman was busily engaged in starting the other pump, reasoning, no doubt, that if one pump couldn't force the water into the boiler, two could.

Calling to the fireman to stop, the engineer ran to the first boiler feed valve, which he found closed. After it was opened the feed pump began exceeding the speed limit, for the throttle was wide open.

Del Monte, Calif. A. C. McHugh.

## Burning Refuse Fuel in a Boiler Furnace

On taking over the direction of a wood-working plant, I found that the refuse burned in the boiler furnace was not sufficient and considerable coal was used with it for fuel. A bed of soft coal would be carried on the grates, and as refuse was brought to the boiler room, it was fired as needed. This decreased the coal fuel consumption, but clinker formed, air holes came in the fuel bed and excessive air entered through the fire-doors because of the frequent firing. Coupled with this, a blower discharged all sawdust into the furnace. This was also variable, allowing excess air at times. Summing up, the efficiency of the furnace was poor.

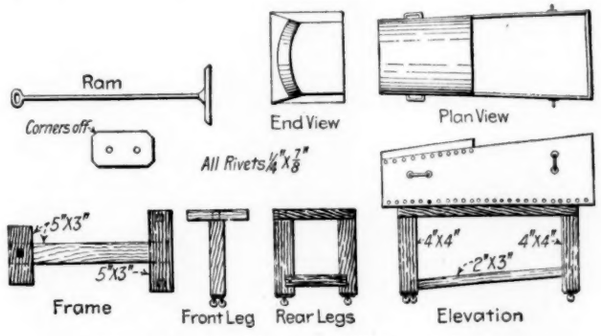



FIG. 1. DETAILS OF FIRING CHUTE

These conditions led to experimenting, and having a proper storage bin for sawdust and a suitable place for refuse near the furnaces, I decided to let the refuse and sawdust accumulate until these receptacles were nearly full and then to burn it separately and obtain the best result from each kind of fuel.

The method employed for burning refuse was not desirable, because as it was shoveled into the furnace, the fire-doors were necessarily opened several minutes and sometimes a drop of from 10 to 20 lb. in pressure occurred. Coupled with this there was a considerable fire risk, as small pieces getting afire and dropping to the floor would sometimes fire the refuse heap.

The refuse consisted of bench shavings and sweepings from cabinet rooms, veneer in all woods and in a variety of sizes (some like wire grass, practically impossible to shovel), trimmings of heavier stock, also edgings and small wood from the mill, plus the sawdust. Some of the veneer had to be picked up by hand and thrust into the furnace mouth in bunches.

In order to charge sufficient fuel at one time to cover at least half of the grates, a chute of $\frac{3}{16}$-in. sheet steel was made, as shown in Fig. 1. Each side was secured to the bottom by an angle iron. The top was held together by a metal hood, and the small end was made so as to enter the furnace door a distance of 2 in. The frame support consists of an I-top with a front leg mortised, as shown, and a double caster fitted to its bottom. The two rear legs have a single caster each. These are held by two radial braces to stiffen them. Two $\frac{1}{2}$-in. round-head bolts secure the frame to the body.

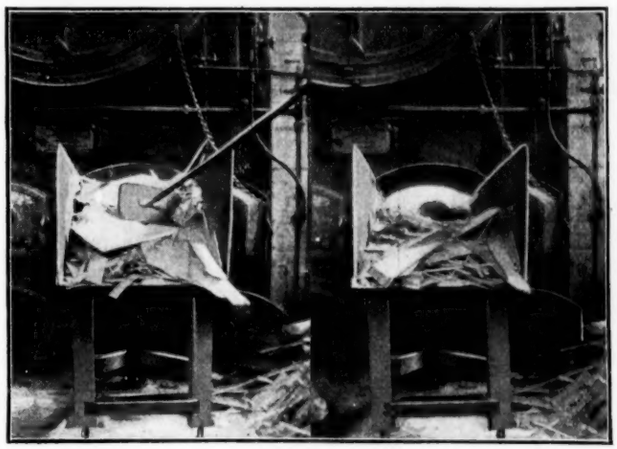


FIG. 2. TWO VIEWS OF THE CHUTE IN POSITION

When about to fire, the chute is pushed back to the refuse pile and loaded. The fire-door is then opened, and the end of the chute is pushed in on the dead-plate. A ram is made with its corners cut so as to clear the angle iron. It is used to shove the refuse from the top into the furnace first, otherwise some of the refuse would jam. The left view of Fig. 2 shows the chute nearly full, also the location of the ram; the right view shows the chute, partly discharged and one shove of the ram will put the refuse onto the grates.

Sometimes, when there is a severe demand for steam, we keep the front end of the chute closed with refuse and the remainder partly filling, feeding gradually until the grates are full. This has given excellent results.

I next decided to connect an 8-in. suction pipe from the system in the mill to the boiler room and down inside a bin, as shown in Fig. 3. A gate was also put in to cut out the supply when not desired. A wooden flare at the bottom prevented choking up. This allowed the feeding of sawdust alone and operating with a damper regulator, thus accomplishing a further saving. An almost constant steam pressure was maintained with the damper from one-quarter to three-quarters closed.

Checking up for a comparison as to the time the fire-doors were open with both methods of firing under the

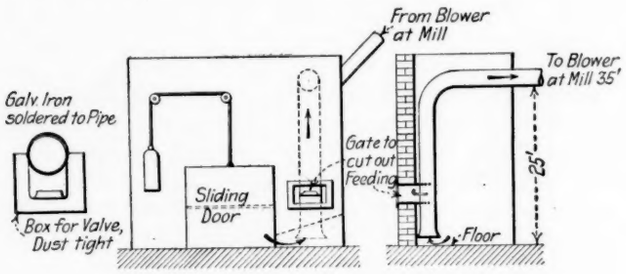



FIG. 3. SAWDUST BIN AND DISCHARGE PIPE

same conditions, all was in favor of the chute feeding system. The chart, Fig. 4, shows the results obtained. As far as the labor is concerned, it is a little in favor of the stoker. Of course the sawdust that accumulated had to be shoveled into the furnace as before. The total cost of the firing chute complete was $21.

The approximate evaporation per pound of fuel was with the old method, mixed fuel, 4½ to 6¾ lb.; with the new method, all coal, 9½ to 10½ lb. of water. No data are at hand to show what evaporation is obtained per pound of refuse fuel. We have made a reduction of 18 per cent.

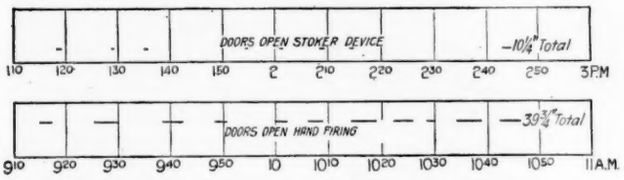



FIG. 4. COMPARISON OF OPEN FIRE-DOOR PERIODS

in the fuel bill in 8½ months' operation with the new system.

The central station had made tests on this plant and was about to submit a bid. This was deferred by the new showing, and it is safe to say that with other improvements another isolated plant will be saved.

Boston, Mass. F. J. MacDonald.

## Extension Cords Dangerous

Without a doubt the lessons we learn best are those which are taught by the time-honored teacher, Experience. When I read R. K. Long's article on "Boiler Room Electrocution," in *Power*, Mar. 13, it recalled an experience that I had about four years ago while inspecting the inside of a condenser after repairs had been made. I had entered the condenser through the turbine manhole and was standing in the exhaust bell with my feet, which were wet, braced against the center stay. The machinist had just finished the job and left his extension light hanging in the casing. When I picked up the lamp by the socket it was "something heavy." The socket was in contact with one side of the circuit, and the shock that I received was so severe I could not get clear of the lamp; neither could I use the other hand, but I still stuck to the center stay. My only chance of breaking clear of the circuit seemed to be falling to the bottom of the condenser some 10 ft. below, when one of the men happened to be passing outside and heard my struggles and pulled the lamp out of my hand.

This all happened on a 110-volt extension-cord lamp circuit. Such an encounter is convincing that low voltage is dangerous. The immediate result of this experience was that on all extension circuits ordinary duplex extension cord and brass sockets were discarded, and in their place was substituted heavy rubber-covered duplex wire inclosed in a single reinforced covering connected to a fiber-type of socket. J. C. Hobbs.

Pittsburgh, Penn.

## Thickness of Dished Heads

In the issue of Mar. 6, page 313, there is a chart for determining the thickness of dished heads, with two problems worked out. In the second example, where the tank diameter is 60 in. and the head dished to 42 in., designed for 150 lb. pressure, $\frac{7}{16}$ in. is given for the convex and $\frac{5}{8}$ in. for the concave head. I worked this problem by means of the formula and chart and do not agree with these results, as I get 0.485 in., or ½ in., for the convex and 0.725 in., or ¾ in., for the concave head.

For Convex Head: $P = 150$; call $L = 0.8 \times 60 = 48$ in.

$$t = \frac{5.5 \times 150 \times 48}{2 \times 55{,}000} = 0.36 + \tfrac{1}{8}\ in. = 0.485\ in.\ or\ \tfrac{1}{2}\ in. = t$$

For manhole in head, $t = \frac{5}{8}$ in.

For Concave Head: $P = \frac{150}{0.6} = 250$: $L = 48$ in.

$$t = \frac{5.5 \times 250 \times 48}{2 \times 55{,}000} = 0.6 + \tfrac{1}{8} = 0.725\ in.,\ or\ \tfrac{3}{4}\ in.$$

With manhole in head, $t = \frac{7}{8}$ in.

If I am wrong, please correct me. If you are wrong, kindly make correction in *Power* if you have not already done so. L. Seilig.

Chicago, Ill.

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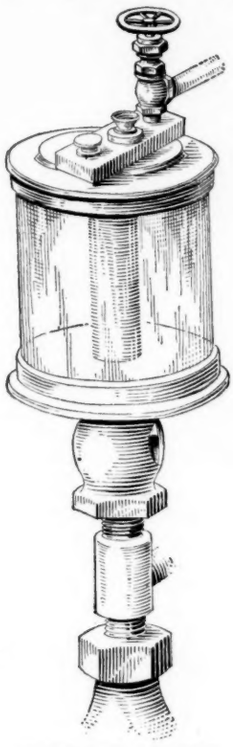
The difficulty lies in the example given with the diagram, which should read: "For a 60-in. tank, head dished to 42 in., 150 lb. pressure, 42 in. is less than 80 per cent., therefore, read down on 60 in. (instead of 48) to 150, to left find ½ in. for convex, and ¾ in. for concave. If the heads have manholes, they should be ⅝ and ⅞ in. respectively."

The diagram could have been made without the upper set of figures, but it was thought best to emphasize the 80 per cent. limit, and for this purpose the upper set of figures was set over so that the diagram could be read directly from the diameter of the tank instead of from the radius of head, which could have been read up from the bottom of 48 in., which is 80 per cent. of 60 in the example given. The author regrets the error and hopes this will make the matter clear. E. W. Ashenden.

Minneapolis, Minn.

# Telescopic Oiler Discussion

Answering J. B. Walker's request for information, in the issue of Apr. 3, page 463, on how to overcome the pumping effect in telescopic oilers, I think from the brief description that his oilers are the same type as those we have on one of our cross-compound engines on both the high- and low-pressure crossheads, from which excellent service is obtained, and in our case after an eight-hour run the floor is (as far as the oiler is concerned) just as clean as when starting up. If a pumping action is obtained, it is obvious that more or less of a vacuum is produced, and it will be necessary to break the vacuum or, better still, prevent its formation. The illustration shows how this is done in our case. The tee between the oil cup and the pipe has an open side, and the formation of a vacuum in the oil pipe under these conditions is impossible. We carry an oil pressure of about 35 lb. and feed a continuous stream to the cup over the oiler. From my own experience I consider this oiler far superior to any wiper I have ever seen.



OPEN TEE BELOW CUP

A. D. Palmer.

S. Quincy, Mass.

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I have been surprised to find that some engineers are not favorable to telescopic oilers as fitted to crossheads. In our plant we have had four running for about four years and giving complete satisfaction. We have two cross-compound units: one 14 and 28 x 30-in. stroke, 150 r.p.m., and one 21 and 42 x 36-in. stroke, 120 r.p.m. There is no difficulty as regards the oil pumping out of the sliding tube unless the oil is turned on full, in which case the trouble is from the relatively small area and motion of the bearing—the oil cannot get away fast enough. We find that two or three drops per revolution is ample to keep the crosshead pins perfectly cool. In the case of the eccentrics a full stream may be turned on without pumping out oil, owing, of course, to their larger area, higher speed and continuous revolution. And here I would note that we find that the eccentrics run cooler with one drop of oil per revolution than with a full stream. I find difficulty in explaining this fact, but I have verified it many times. While accepting the theory that a continual stream of oil is ideal, I am confronted with the fact that increasing the supply to our eccentrics causes them to run warmer.

Returning to the case of the crosshead pins, the average wiper arrangement will not give more than two or three drops per revolution, delivered into the bearing; much that runs from the cup is lost on the floor, and it must be a badly designed telescopic oiler that will not pass this amount of oil without pumping it out at the sliding sleeve. Further, it seems to me that the "head" afforded by the telescopic oiler is a valuable feature in case the oil channels become clogged. By opening up the oil supply full, it is possible to increase this "head" by that due to the elevation of the supply tank. The wiper system affords no such facilities to remove obstruction in the oil channels.

John L. Sheldon.

Prince Albert, Sask., Canada.

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I prefer the telescopic oiler wherever it can be used, from the following experience: A 12 x 12-in. engine of the center-crank type was fitted with a "wipe oiler" for the crankpin, which did not give satisfaction, and as there were no means of attaching a centrifugal oiler, a telescopic oiler was bought and put on. It did not work well on account of the oil accumulating in slugs in the pipe and being thrown out so that very little got to the pin.

To remedy matters I obtained a piece of smooth brass pipe large enough to slide over the original outside pipe and made the original outside pipe the inside one, retaining the top and bottom fittings and put a vent hole in the top fitting so that the pumping action could not force air back into the oil cup and break up the oil drops. After making these changes, the oiler worked very well and has been running for three years or more. It throws a little oil, but considering the speed and length of the pipes, it does well.

C. F. Danner.

Lacombe, Alta., Canada.

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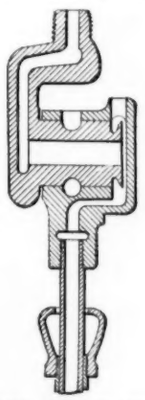
I fail to see how any operating engineer can prefer wipers and oil boats to telescopic oilers except on slow-moving engines, and then only where the bed of the engine has not been designed to drain the oil off into a filter. My experience with both types in one plant follows: It was a common thing to have oil spatter all over the floor at the side of the engine from the wiper, although only a half pint was fed in three hours. On another engine with a telescopic oiler three quarts was fed and none was spilled on the floor. Of course it all depends on the quantity of the flow to the telescopic oiler, whether it will throw it out or not. There are three $\frac{3}{32}$-in. holes drilled in the top of the outer fitting as an air vent, and if too large a stream is allowed to flow, as in our case (the tank was thirty feet above the engines), the pressure will force the oil through these holes and it will overflow. I have never experienced any trouble with the pumping effect spoken of by Mr. Walker. The illustration shows the swing joint of the oiler referred to. The bottom swivel is the same except that it has only one air hole.

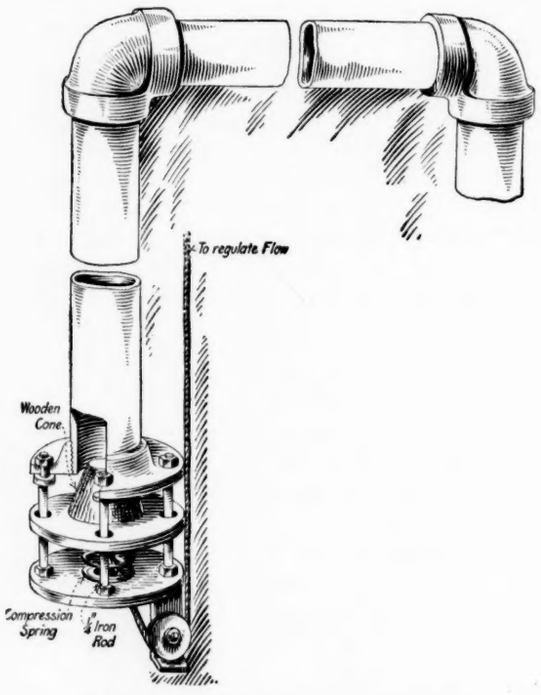


UPPER SWING JOINT

Stratford, Ont., Canada. H. T. Westwood.

## Regulating the Flow of Siphon

The objection is sometimes raised to the use of a siphon in draining pits, that it is difficult to regulate the flow so that when the pit is entirely drained the pipe will draw air, necessitating priming it again, and this continual priming might involve more labor than the direct




REGULATING VALVE FOR SIPHON

use of a pump. Regulation of the flow of a siphon to any degree up to the capacity of the pipe can be secured by use of a valve made as here described or modified to suit any particular conditions met with in the various uses of a siphon.

The essential parts are shown in the illustration and consist of three flanges fitted to the discharge end of the siphon pipe, four rods, a compression spring, a cone-shaped piece of wood and a piece of rope. One flange is screwed to the end of the siphon pipe and connected to a second flange, by the four rods equally spaced. The cone-shaped piece of wood, which acts as the disk of a valve, seats on the third flange, which is guided by the four rods and forced to its seat by the spring. The rope can be attached to the lower end of the wooden cone and is used to pull the disk away from the mouth of the pipe, thus regulating the flow of water. The spring at all times tends to return the disk to its seat. To make a better job the cone could be covered with rubber packing.

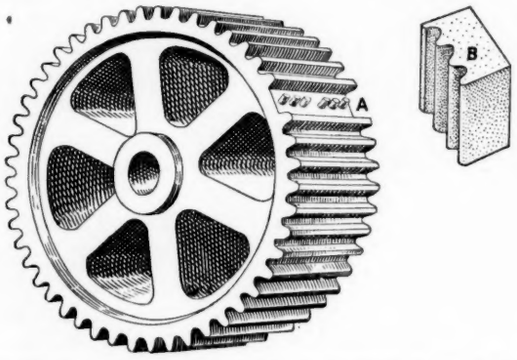
In operation the longer leg of the siphon is filled with water and the other end placed in the pit that is to be drained. The rope is then pulled, and the water in flowing from the pipe will draw the water from the pit, the amount of water flowing being controlled by the valve opening. To stop the siphon, the rope is released allowing the disk to return to its seat, thus entrapping the water in the long leg, until it is desired to start the siphon again. This means is preferable to the common practice of throttling the intake.

Richmond, Va. JAMES M. PURCELL.

## Pump-Gear Repair Job

The illustration shows a repair job that was made on the intermediate gear of a large direct-connected motor-driven pump. Several teeth were broken out, a new gear could not be obtained for about two weeks, and it was necessary that we get the pump running with as little delay as possible.

The broken teeth were chipped out flush with the bottom of the gear rim and a row of $\frac{7}{16}$-in. holes drilled and tapped across the face of the gear where the teeth were broken out. Pins threaded their entire length were




HOW BROKEN GEAR TEETH WERE REPAIRED

screwed in, projecting the height of the teeth, as shown at *A*. A plaster cast of several whole teeth was then made, as shown at *B*. After thoroughly drying out the cast, it was placed over the pins and a tooth of hard babbitt metal poured. After all the broken teeth had been repaired in this manner, the gear was replaced on the pump and it ran for about two weeks, until a new gear was procured. When the repaired gear was replaced with the new one, it was hard to tell which were the repaired teeth.

B. J. CRAGGY.

Nashua, N. H.

## Stop-and-Check Valve Failed

An automatic nonreturn valve on one of the boilers in the plant of the Illinois Traction Co. at Venice, Ill., failed not long ago. There are 8 water-tube boilers in the plant of 600-hp. capacity each, all equipped with superheaters. The working pressure is 180 lb. with 100 deg. superheat. Each boiler had a globe-pattern stop-and-check valve.

One of the boilers had been "loafing" along during the day with a banked fire and the stop-and-check valve automatically closed. Toward evening the fire under this boiler was livened up, and it is probable that no attention was given the indication of the steam gage while the pressure was rising—dependence being placed on the automatic action of the valve. Presently the valve opened and immediately closed, opened and closed again, and then, on the third opening, the body of the valve broke in two just beneath the bonnet flange, while a large piece was blown out of its side.

The pressure in the system dropped to about 20 lb. before the flow of steam from the seven boilers already in service could be checked. As far as known, no one was seriously injured as a result of this accident.

St. Louis, Mo. A. J. DIXON.

# The Steam Locomotive as a Power Plant

Your comment on V. W. Zilen's suggested steam turbine for locomotive drive, as published in the May 1 issue, could have gone further.

Locomotives are run for long periods at reduced speeds, at the same time frequently being compelled to exert their maximum tractive effort. Such conditions are not favorable to the steam turbine unless indeed speed-changing gears are to be used, which does not seem practicable.

The trouble with the locomotive is not in the engine. Under favorable conditions it shows good steam economy. Published results equal those obtained in stationary plants using either turbine or reciprocating prime movers, operating with the same steam pressure, superheat and back pressure. The boiler and furnace end of a locomotive, however, might well be described as a crime against civilization, considering our diminishing coal reserves and the large portion of the annual coal production consumed by locomotives.

Not only is the locomotive most wasteful, but it further fails to meet the requirements of business. The question troubling railroad men most of all is that of capacity. They want to haul longer trains up limiting grades and at greater speeds, to handle more business with present equipment and labor charges. Some roads have even gone to the length of putting two boilers on a locomotive, in spite of the complication and unhandiness of such a unit, and others are experimenting with mechanical stokers as an alternative to placing two firemen on a locomotive and with the object of increasing hauling capacity, which at present is limited by the amount of coal that can be burned in a firebox as wide as can be carried on the present gage and as long as can be stoked by a human fireman.

### High Draft Responsible for Back Pressure

The high rate of combustion per square foot of grate now used implies a high draft, amounting at times to a suction of as much as 10 in. water column in the firebox. This draft is maintained in about the most inefficient way that could be imagined: namely, by using the exhaust from the engine in a steam ejector formed by the exhaust nozzle and the stack. To obtain the blast required, a back pressure is put on the engine cylinders that at high speed and heavy pulling reaches 20 or 30 lb. per sq.in., thus reducing materially both the hauling capacity and the efficiency of the engine.

Without going into details and figures, it can safely be assumed that:

1. By using mechanical-draft fans instead of the engine exhaust to produce the draft, the steam consumption of the engine can be reduced 10 to 15 per cent. or more, with an expenditure of steam for driving the fans of only 2 or 3 per cent.

2. By utilizing some of the exhaust steam from the engine for heating the feed water, the steaming capacity of the boiler can be increased 15 per cent. while using the same amount of fuel, or the fuel consumption can be reduced by a like amount while maintaining the same rate of steaming.

In other words, the tractive effort under maximum speed and load conditions can be increased at least 10 or 15 per cent., while the power that can be developed from a given size of boiler and weight of fuel can be increased 25 or 30 per cent. by the simple introduction of a mechanical-draft fan and a feed-water heater.

3. The ample draft that is obtainable with a turbine-driven fan, however, makes possible still further economies, since it permits the use of ample superheater and economizer surface and of high gas velocities, which would give high rates of heat transmission through such surface. The superheater and economizer would not entail further loss of power from back pressure on the cylinders, as at present. By means of a good superheat 15 to 20 per cent. more power can be obtained from a given weight of boiler and fuel, while an economizer receiving water from the exhaust heater at 210 deg. F. could easily deliver it to the boiler at 300 or 350 deg. F., the temperature of the gases leaving the front end of the boiler now being about 700 deg. to 800 deg. F. The economizer would thus increase the boiler capacity and efficiency by another 9 to 14 per cent.

### Amount of Cinders Cut Down

4. Cutting down the coal consumption in any such ratio as indicated will decrease the amount of fuel burned per square foot of grate enough to reduce sensibly the amount of fuel lost as cinders, as it has been found that the throwing out of cinders increases rapidly after a certain point, nearly as the cube of the rate of combustion.

The savings mentioned can be added together; that is, making one does not cut out the others, although there is some conflict between the exhaust heater, the economizer and the superheater. In other words, if an exhaust heater is put in, the water will be hotter when it reaches the economizer and naturally will not absorb the heat so readily, while the superheater will cool some of the gases going to the economizer. Nevertheless there is a possibility of increasing the power capacity of the locomotive—that is, the horsepower that can be developed from a given weight and size—by 30 to 50 per cent., with an equal saving of fuel. This is the more notable when it is considered that the weight of locomotives is now limited by the strength of the track structure to so much per wheel, while the size is hampered by the clearance limitations of bridges, tunnels, etc.

5. Exhaust steam, of which there will still be a large surplus going to waste, can also be used in the winter time for heating passenger trains, which is worth while not only because of the considerable percentage of boiler capacity now required for heating with live steam, but also because all possible power is needed in cold weather for hauling, on account of increased resistance due to increased viscosity of the lubricants used on the car axles.

I am not blind to the practical difficulties involved in the foregoing proposals, particularly in connection with the draft fan. Smokeboxes and blast nozzles are even now badly cut by cinders, although protected by screens of heavy and fine mesh. It is possible, however, to eliminate the cinders by some form of separator.

What is really needed is some one in the locomotive business to take the bull by the horns and build a locomotive on which these arrangements are used, and about the only people in a position to do so with any hope of returns upon the large expenditure required for research and development are Baldwins or the American Locomotive Co. Superintendents of motive power and master

mechanics are too fully occupied with their routine duties and are too afraid of having the locomotive stop on the road for them to take any chances in radical departures. Other railroad officials take little interest in mechanical matters or in mechanical people.

It might seem that the experimental departments of some of the great railroad systems would take up research of this kind, but their attention appears to be concentrated on detail improvements, amounting possibly to a great deal when spread over their large volume of business, but nothing revolutionary or radical.

New York City. GEORGE H. GIBSON.

## Experience in a Small Municipal Plant

When, owing to the war, I lost my position as a designer I was obliged to go outside of the drafting room for one, as positions in my line of work are scarce. I answered an "ad" for chief engineer of a small city pumping station. The plant did not look so very bad except for leaky joints and broken drip lines, but the superintendent thought it was a pretty nice station and, as I needed the position, I agreed.

The station consisted of four 200-hp. water-tube boilers with very good settings, two 125-hp. fire-tube boilers with the worst settings I ever saw, all fired with natural gas. There were two compound 1,000,000-gal. direct-acting Laidlaw-Dunn-Gordon pumps twenty years old, one 2,000,000-gal. compound Blake-Knowles (with one side out of line) used as a reserve unit, and one direct-connected turbine-driven two-stage centrifugal pump, all high-head units. For pumping from the river to the settling basin there were two small A. B. C. engines connected to low-head Worthington centrifugal pumps. All units were operated noncondensing with the exhaust going through a feed-water heater.

To operate and keep up repairs there were two men besides myself, and each worked eight hours except on Sunday, when two men worked 12 hours each, this giving each man every third Sunday off. One of the men was a very good engineer, but the other, although he had been at the pumping station for twenty years, could be called only a "starter and stopper," and I consider that the chief engineer before me did well to keep the station running at all with the help he had.

As the board would look for improvement in the plant, it was up to me to get something done that they would notice. This was easy, for after I had fixed a broken cylinder drain, put some pipe clamps on the main steam-line flanges, put in a few new gaskets and packed several valve stems, the appearance of the pumproom was improved wonderfully and the board commented favorably on the change.

Several tubes gave out in the water-tube boilers because of scale, so I suggested to the superintendent that we could cut out the boilermaker's bills by getting another engineer to help me, taking my shift and making it possible to do work that one man could not do alone; which was done.

The turbine was not running as it should and was getting worse, so the board decided to get an erecting man from the factory to overhaul it. The turbine had run about four years 24 hours a day without a cent spent on it for upkeep. It vibrated excessively, and the governor valve was stuck in a wide-open position. (I hate to think what would have happened if the pump had lost its suction.) The erecting man dismantled it and found the bearings worn down so far that it allowed the wheel to rub the edges of the buckets, which were also cut back five-eighths of an inch by moisture in the steam. After the overhauling the turbine ran fine, and the next thing was to line it up with the pump. To do this, we were obliged to take out $\frac{3}{32}$ in. of shims from under the turbine. Imagine a 1900-r.p.m. turbine running $\frac{3}{32}$ in. out of line with a pump for four years! A word of explanation will show why the turbine and engines were not lined up correctly. When the station was rebuilt, instead of having an erecting man from the factory, they gave the job of installing the turbine, engines and pumps to a concrete contractor who evidently thought that it made no difference if they were out of line, having a flexible coupling.

Next turning my attention to the high-speed engine sets, I took the coupling bolts out and found the pump half of coupling $\frac{1}{16}$ in. higher than the engine, so had to shim the engines up. I took the piston out, and of the two piston rings there was just one piece about 2 in. long left. How they ever got out without scoring the cylinder or breaking the piston valve is more than I know.

### Blowoff Piping in Dangerous Condition

The blowoff nipples in the water-tube boilers were standard-weight pipe, and when replacing them with extra-heavy brass pipe, I found that where the threads were cut they were about the thickness of writing paper. If one of these had ever let go when blowing down (every shift), the engineer would have had no chance to escape being cooked alive. A large part of the feed-water piping was standard weight, and if some of these pipes had let go and scalded a man to death, the chances are it would have been blamed on me, when rightfully it would be up to the management and state. (No boiler laws.)

The foregoing were just a few of my many troubles. One of the greatest handicaps was the fact that I did not have the authority to "hire and fire" my own help. The board balked when I asked for this, but after I left the station they had a series of "events" that caused them to give such authority to my successor, which is just if they expect him to get results.

One thing that struck me as peculiar, was that they hired men to run the plant and then did not follow their advice as to what was needed. For instance, to increase the station's capacity, I advised the installation of a condensing steam turbine geared to a centrifugal pump, as this would have cut the fuel bill in half and given good feed water, besides allowing a shift over to the plunger pumps in case of accident. The consulting engineer presented for their choice four propositions, and they chose a gas-engine unit. This would have been all right if installed in duplicate, but they bought only one and it must run twenty-four hours a day. If anything happens to it, steam must be raised in the boilers (from two to three hours' time) and the steam-driven units put in service. The first cost and interest charge on the gas engine was about twice that of the steam turbine, and depreciation is also greater.

My experience has led me to wonder how many plants, municipal and otherwise, throughout the country are in the same condition and whose chief engineers have to work under similar handicaps. KARL MACDONALD.

Hartford, Conn.

# Inquiries of General Interest

**Current Density in Busbars**—What is the allowable current density in switchboard busbars? B. T.

In general practice where the laminations are not made over 0.25 in. in thickness, 1000 amp. per sq.in. of cross-section has been found to be satisfactory. It is better to use thinner laminations, as this will result in a lower temperature of the copper. For alternating-current work a single-strap bus can usually be worked at about the same density as for direct current. However, for multiple-strap busses it is not advisable to use current densities above 600 amp. per sq.in. for a 25-cycle and 400 amp. per sq.in. for a 60-cycle system.

**Transformer Regulation**—In reference to a transformer, how is the per cent. regulation expressed and how is it affected by the power factor? A. T. C.

In general terms the per cent. regulation of a transformer is the per cent. variation in the secondary voltage from full load to no load. For example, the voltage of a transformer, at no load, is 120 and at full load 114 volts. Then the per cent. regulation $= \frac{(120 - 114) \times 100}{114} = 5.3$ per cent. The voltage varies inversely as the load, provided the power factor remains constant. A lagging power factor tends to decrease the voltage whereas a leading power factor tends to increase it, thereby improving the regulation.

**Cleaning Scale from Gas-Engine Water Jacket**—How can the cooling jacket of a gas engine be cleaned of scale deposited out of the cooling water? W. M. G.

Scale formed by most waters can be softened by a strong solution of caustic soda, but the process is slow and not very efficient unless the jacket can be kept warm during a number of treatments with a fresh soda solution and alternate washing out with clean water. A quicker removal of scale generally is obtained by repeated treatment of a solution of commercial muriatic acid and an equal quantity of water, with care that the solvent action of the acid is not continued to the extent of damaging the walls of the water jacket.

**Height of Pumping Water with Tank Pump**—To what height can water be pumped by a single 6-in. x 8-in. x 8-in. steam tank pump supplied with steam at 90 lb. boiler pressure, with pressure of the water supply 5 lb. per sq.in. and discharge pipe 3 in. extended horizontally a distance of 200 ft. and then vertically to the top of a tank? E. W.

The height to which the pump can raise water would depend on the rate of discharge, as the frictional resistance of the water passages of the pump varies for different speeds and the frictional resistance of the discharge pipe would depend on the velocity of the discharge as well as the size and length of the pipe. With the pump running at a piston speed of 75 ft., or 112.5 single strokes per minute, it would have a mechanical efficiency of about 70 per cent., and when supplied with steam at 90 lb. gage pressure the discharge pressure would be 70 per cent. of $90 \times 6^2 \div 8^2 = 35.43$ above the suction pressure, or a total pressure of $35.43 + 5 = 40.43$ lb. per sq.in., or $40.43 \times 2.3 =$ practically 93 ft. head at the pump. Allowing 7 per cent. for slippage, the rate of discharge would be $(8 \times 8 \times 0.7854) \times 8 \times 112.5 \times (1 - 0.07) \div 231 =$ 182.1 gal. per min. By consulting tables or diagrams giving loss of pressure in different sizes of pipes for different rates of flow, it may be seen that discharge of water through a 3-in. pipe at the rate of 182 gal. per min. entails a loss of about 0.11 ft. head per foot length of the pipe; hence the pipe frictional loss, discharging through 200 ft. of horizontal run, would amount to $200 \times 0.11 = 22$ ft. of head, leaving $93 - 22 = 71$ ft. head for raising the water in the vertical section of the pipe. Allowing the same loss of head per foot of vertical pipe, each foot of the head remaining for overcoming pipe friction and the static head would be capable of raising the water $\frac{1}{1.11}$ ft. and the total height to which the water could be raised above the pump would be $\frac{1}{1.11} \times 71 = 64$ feet.

**Lap of Corliss Steam Valves**—Why are the steam valves of a single-eccentric Corliss engine set with lap, and why do different engine builders recommend different amounts of lap for the same size of engine? G. B. W.

Having the exhaust valves set with little or no lap when the wristplate is in its central position, to obtain release and compression of the exhaust before the end of the stroke it becomes necessary to have the eccentric set more than 90 deg. ahead of the crank. As advancing the eccentric makes all events earlier, the lead thereby becomes earlier, and with all valves lapless the closing of the exhaust port would occur at the same time that the steam port opened on the same side of the piston, and instead of compression there would be excessive lead. Hence the steam valve is set with lap so the steam port will be kept covered until it is desirable to have the live steam admitted. The amount of lap recommended by different builders varies on account of their selection of different points for release and compression and also on account of difference in proportions of valve gears.

**Dry-Back and Wet-Back Scotch Marine Boiler**—What is the difference between a dry-back and a wet-back Scotch marine boiler T. P. M.

In each kind the grates, as shown in Fig. 1, are placed in the furnace flues, of which there may be one or more. Back of the bridge-wall the furnace flue or flues connect with the combustion chamber A, Fig. 1, or B, Fig. 2, and from the

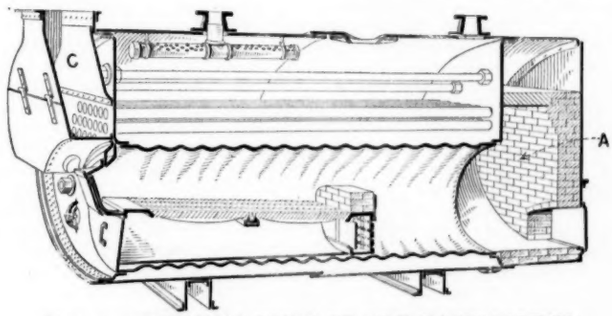



FIG. 1. SECTIONAL VIEW OF DRY BACK SCOTCH MARINE BOILER

combustion chamber the gases pass through a large number of fire tubes to a smoke uptake at the front, such as shown at C, Fig. 1. In the dry-back boiler, which generally is used for stationary work, the combustion chamber, formed by extension of the shell, usually is provided with a firebrick

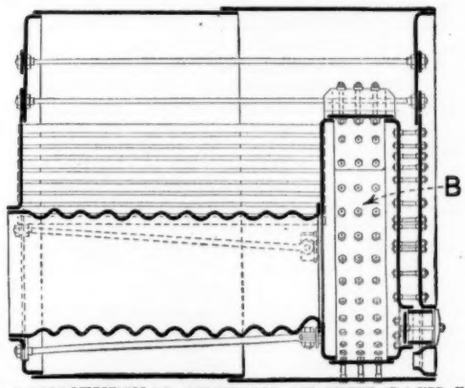



FIG. 2. LONGITUDINAL SECTION OF WET BACK SCOTCH MARINE BOILER

lining, as shown in Fig. 1. In the wet-back boiler the combustion chamber is formed by extension of the steam and water spaces of the boiler around the combustion-chamber space, as shown in Fig. 2, the water-leg at the rear forming the "wet back."

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[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

# Evolution of the Steam Turbine*

*SYNOPSIS—The paper brings together many facts and data pertaining to steam-turbine practice that are of scientific and commercial interest to those engaged in steam-power-plant engineering.*

From surprisingly small beginnings in 1883, the steam turbine has been developed, and has grown to such proportions that it has invaded practically every field formerly occupied by the piston steam engine. The reasons for this are obvious.

1. The first cost is considerably less. In the case of a 1000-kw. turbo-generator and a 1000-kw. engine and generator together with necessary appurtenances, the cost of the turbine is 40 per cent less than the cost of the engine. The cost of the turbine unit with reduction gears for mechanical drive is approximately the same as the equivalent engine for the same type of drive.

2. Purely rotational motion and light weight permit it to have much smaller foundation.

3. The floor space occupied by the turbine is much less than that occupied by the piston engine—from 75 to 90 per cent. of the space being conserved.

4. The steam consumption for condensing turbines in large units is decidedly superior to engines running with the same pressure and superheat. In sizes ranging from 200 to 1000 kw. there is a wide variation between various types of turbines and various types of engines. In some cases the advantage is slightly in favor of the turbine, in others in favor of the engine. However, in the latter case the engines are of the highest grade and the first cost is considerably higher than that of engines of an inferior type. In units smaller than 200 kw. or about 300 b.hp., the engine has slightly better economy, especially the newer types of poppet-valve and uniflow engines. For noncondensing operation where there is no use for the exhaust steam, the steam engine has appreciably better economy except in the case of steam pumps, such as used for boiler-feed purposes.

5. The steam turbine, however, has other features which will tend toward still better economy, due to the use of higher steam pressures and superheats that would be out of the question with steam engines.

6. Because of its relatively simple construction, the turbine requires very little attention other than starting and stopping and occasional inspection.

7. The entire absence of large reciprocating parts and the presence of few small ones means that maintenance is small. The early machines, in which the nozzles, blading and buckets were made of steel or iron, were subject to considerable erosion, which ran the maintenance cost up rather higher than necessary, but the introduction of bronze, monel metal and other alloys has eliminated this trouble.

8. Because of the light weight and the absence of friction surfaces in the steam spaces, the cost of lubrication is only one-tenth of that of a steam engine. Lubrication, however, is just as important, and cessation of the oil supply would be more disastrous in a shorter time.

9. The uniform rotational velocity due to continuous supply of steam as distinguished from the intermittent action of the steam engine and the superior governing of turbine results in smoother operation of all machinery connected to it, and therefore tends toward increased production.

10. This system of driving eliminates the use of large flywheels.

11. Perhaps the most important characteristic is the fact that the turbine can be built in almost unlimited sizes. A single unit of 70,000 kw.[1] (about 100,000 hp.) is now under construction, and larger units are contemplated. In this field, engine-driven units above 5000 kw. are very uncommon, although larger units have been used on ocean-going steamships. The largest reciprocating engine which we know of is being installed at the Lukens Steel Co. and is to develop 25,000 hp., which is equivalent to 16,500 kw. The largest reciprocating marine engines are capable of developing 17,000 hp., or 11,000 kilowatts.

12. It is rather interesting to note the amazingly short time in which the development of the steam turbine has taken place and the correspondingly long time for the steam engine. The perfection of the turbine has given new impetus to the steam engine, no radical improvements on which have been made for a long time, and better economies on the smaller sizes are now being realized, but not of course without additional cost. The competitive influence which the small engine has upon the turbine is an advantage which will stimulate further research and investigation, so that better economies may be continually expected.

*Abstract of a paper entitled "The Evolution of the Steam Turbine in the Textile Industry," by John A. Stevens and associated engineers, read at the annual meeting of the National Association of Cotton Manufacturers, Boston, Mass., Apr. 25 and 26, 1917.

[1]The actual maximum rating of the unit will be 60,000 kw.—Editor.

## LOW-PRESSURE, MIXED-PRESSURE AND EXTRACTION TURBINES

The superior steam economy of the noncondensing steam engine over the noncondensing steam turbine suggested the use of the "low-pressure" turbine, running on steam exhausted from a noncondensing engine, which resulted in a combination that rivaled any previous records in steam consumption per horsepower. The steam engine operates most economically down to atmospheric pressure, the gain by condensing being only 25 per cent. The turbine, on the other hand, operates most economically from atmospheric pressure down to the vacuum usually employed, the gain by condensing being from 80 to 100 per cent. In other words, nearly as much energy is realized from atmospheric pressure down to 28 in. vacuum as from boiler pressure down to atmospheric pressure. All points must be very carefully considered in installing a low-pressure turbine. Division of load for a proper steam balance involves more or less complications which require intimate knowledge of operating conditions. If both engine and turbine drive to the same headshaft or through generators to the same busbars, the load can be automatically distributed between the two units in such a way that the turbine will always use all the steam supplied by the engine—no more and no less. If each unit drives an independent load, at times the engine may not deliver enough exhaust and at other times it may deliver too much, the surplus being wasted. In case one unit is on electric drive, this can be remedied by tying in a dynamo with both systems; in case the engine when furnishing an excess of steam, the turbine will take it and furnish mechanical power through the dynamo acting as a motor and cutting down automatically the power and steam consumption on the engine; in case of insufficient exhaust, the dynamo acts as a generator, delivering electric power to the other system, again insuring equal distribution of steam. If both units are on mechanical drive, the load can be equalized by the use of two dynamos interconnected electrically, either one, as conditions require, driving as a generator from its system to the other acting as a motor.

To eliminate the complications of balancing the steam and power between units and to allow for the case where there is always a deficiency of exhaust, the mixed-pressure turbine was developed. This is nothing more than a low-pressure turbine, with a number of high-pressure nozzles which operate when there is a deficiency of exhaust. Such units may now be had from some makers, in which the entire load may be developed on either high- or low-pressure (exhaust) steam, or any combination of both, without any manual attention whatsoever. Low- and mixed-pressure units are now rapidly becoming obsolete for the reason that it appears to be more economical to install complete new high-pressure units rather than low-pressure units on old engines. Engines are seldom found in textile mills which are less than 15 years old.

Perhaps one of the most important and convenient developments of the steam turbine is the so-called "extraction or bleeder" type unit. In the extraction unit steam is taken out from one of the upper stages at from 2 to 15 lb. pressure (in some cases as high as 75 lb.) and is subsequently used for heating or manufacturing purposes. This is done automatically and in any quantities from nothing up to the throttle capacity of the machine. It is probably due to the demands of the textile industry, more than any other, that this type of machine was developed. The steam so extracted is absolutely free from oil and can be used with great economy without any danger to product for any use the industry demands, such as dyeing, bleaching, slashing, etc., in addition to drying and heating.

In addition to the low-pressure, mixed-pressure and extraction units, there are turbines built which involve combinations of these features.

## THE TURBO-GENERATOR AND ELECTRIC DRIVE

Perhaps the widest application of the steam turbine is in turbo-generators for electric drive. The first large steam turbine and electric generator unit in this country was a 1500-kw. nominal rated machine, but having a maximum

capacity of 1900 kw., which was installed by the Westinghouse Electric and Manufacturing Co. at the Hartford Electric Light Co., and started in April, 1901.

The first units for use in a textile mill were a 400-kw. machine installed by the same company at the Atlantic Mills, Providence, R. I., in 1903, and a 1000-kw. machine installed by the General Electric Co. at the Farr Alpaca Co. in Holyoke, Mass., in 1904. In all sizes of units above 200 kw., where fuel must be used to produce electric energy, the steam turbine, in first cost, in reliability and in ease of operation, possesses such advantages over all other prime movers as to be practically free from competition except when conditions are in some way special or peculiar. The steam turbine alone makes possible the large-sized units which today are becoming so frequent in central stations and which are establishing records for economical operation before thought impossible.

Much has been said for and against mechanical drive. When considered from the point of view of first cost, the turbine electric plant, together with the necessary switchboard, motors, wiring and belting, will usually cost materially more than an all-mechanical transmission and this notwithstanding the fact that high-class engines alone are much more expensive per unit of power produced than are turbines of the same class. This is not the equivalent of saying that in any given instance mechanical driving is, therefore, the method to be chosen. The electric drive, because it usually takes up less of the valuable space in manufacturing rooms, because it eliminates heavy shafting drives and cumbersome beltways with their attendant fire risks, because of elimination of the flywheel hazard and because of its flexibility in allowing the best grouping of machinery and the changing of grouping or of machinery from time to time, may often prove more desirable than mechanical drive.

Mills having a varying product and load are likely to profit most from motor drive.

Some mills that have a standard product and steady load may find the direct mechanical drive advantageous. Which arrangement is best for any given case can be determined only by investigating the question independently for each installation and taking into consideration all conditions affecting that plant.

## THE STEAM TURBINE ON MECHANICAL MILL DRIVE

The application of the steam turbine in the textile industry has of late years become well recognized.

The first application of the steam turbine on a mechanical mill drive of considerable size, so far as we have been able to learn, was made early in the year 1913, by the Parsons Co., of England, and was a 700-hp. unit for driving a jute mill in Calcutta, India. This was the first of three such units since installed in that country, one of which is for 1250 hp. The turbine was for low pressure, taking steam from old engines. The turbine and engines ran in parallel. The single reduction gear gave a change of speed from 3000 to 300 r.p.m., and the drive from this low-speed shaft to mill shafting was through ropes.

We have within a few weeks heard of another small unit, built by the same company, which was started in January, 1914, in a paper mill at Palton, England. This was a 525-hp. high-pressure extraction-type turbine with double reduction gears changing speed from 5000 to 420 r.p.m. Part of the power was delivered to a rope sheave and part to a direct-current generator on the low-speed shaft. The coal economy of this equipment over the old which it replaced was recently reported by owners to have been about 30 per cent., and the mill output was increased.

A considerable number of direct-drive turbines have recently been erected in this country. We wish to call attention to two installations of this kind that we have ourselves made.

One of these, that at the Jackson Mills of the Nashua Manufacturing Co., is for 1680 hp., at 160 lb. steam pressure and with 28 in. of vacuum, and so far as we know, the largest anywhere in use up to date. It was started in September, 1916, and has since been working in a thoroughly satisfactory manner.

These mills had until recently all been driven by power derived partly from several waterwheels and partly from two high-type vertical steam engines. The power available from the waterwheels, as is usual in the New England section, varies widely at different seasons, so that there has to be a large percentage of relay power covering nearly all units.

The other installation is a 375 maximum horsepower De Laval turbine with speed reduction from 6000 to 600 r.p.m. This is at the plant of the Pemberton Co., in Lawrence, Mass.

The drive here is partly through a belt wheel capable of transmitting 200 hp. direct to mill shafting and partly to a 150 kv.-a. alternating-current generator, coupled to the low-speed shaft. The generator is one that was already owned by this company. The unit serves as a relay to water power and must work under widely varying load conditions.

The turbine is a combined mixed-pressure and extraction machine either taking exhaust steam from old engines and pumps or supplying low-pressure steam to manufacturing and heating as plant condition demands.

The cost of this installation complete was about 40 per cent. of what that of the equivalent complete equipment for all motor driving would have been.

## CONCLUSION AS TO GEARED TURBINES

The adaptability of steam turbines with electric drive to textile-mill work is pretty generally known. We have here given attention to these turbines with mechanical drive because that type is relatively less well known. It is not adaptable or desirable for all conditions, but there are not a few instances, especially in connection with the revision of power equipment for old mills, where this arrangement is worthy of serious consideration. As previously stated, each individual condition should be judged by itself.

There is another phase that has not been touched upon in the foregoing, and that is the improvement of economy in steam consumption with advance in the art brought about partly by refinements in design and partly by increase in size of the generating units.

Three interesting points were brought out in tables presented. First, the steam engine in the smaller sizes is more economical in the use of heat than the steam turbine, the economy being about the same for either turbine or engine at 200 kw., and better for turbines above 200 kw. By the use of gear reduction, however, higher turbine speeds are possible with resulting better economy, and the tendency nowadays is toward general use of gears in the smaller sizes, so that the superior economy of the turbine over the engine may be taken at 100 kw. or even lower.

Second, the economy of the steam turbine increases rapidly with increase in size of units, and for the latest type of turbine in the 1000-kw. size is practically equal to the best economy obtainable in the largest and most economical engine built. Larger turbines, of course, are more economical in proportion, although, for a given type of machine there appears at present to be no appreciable improvement in economy by increasing in size above 30,000 kw. However, the end is by no means in sight.

In the construction of turbines in sizes of over 30,000 kw., structural difficulties arise, and it has often been contended that it would be impossible to build economically single units of much larger capacity. In spite of this fact the General Electric Co. is now building for the Detroit Edison Co. a single unit of 45,000-kw. capacity.

The Westinghouse Electric and Manufacturing Co., however, has proceeded along different lines, and through the advices of the late Henry G. Stott, of the Interborough Rapid Transit Co., has developed the so-called "tandem-compound," the "cross-compound, two-cylinder," and the "cross-compound, three-cylinder." The tandem-compound unit consists essentially of a high-pressure and a low-pressure turbine on the same shaft, driving one generator. The high-pressure end has a first stage of impulse blading and lower stages of reaction blading with one dummy piston to neutralize the thrust of this part of the machine. The low-pressure end is of the double-flow reaction type, exhaust from the high-pressure turbine coming in at the center and flowing both ways through two exhaust openings. This feature eliminates the necessity of balance pistons. In the cross-compound type the unit consists of one high-speed, high-pressure turbine and generator, and one or two low-speed, low-pressure turbines with separate generators. These units have the advantage of utilizing the steam to best advantage, the speeds of the high and low pressure are commensurate with velocities obtainable from the steam at the respective high and low pressures, although for 25-cycle work the individual units are all run at the same speed, because generators of the same size with interchangeable fields are an advantage.

**Workmen's Compensation Act Applied**—A stationary fireman employed on an eight-hour shift in a Hartford power plant was summoned to work overtime on account of the illness of a fellow fireman. Hurrying through a snowstorm to the plant, he arrived in wet clothing and worked twelve hours, alternately exposed to the heat of the boiler room and to the cold air of an open yard into which he was required to wheel ashes. He contracted a cold, which developed into pneumonia, from which he died. On application by his widow under the Connecticut Workmen's Compensation Act for an award of damages it has been decided by the state supreme court that there was no such "accident," as would justify an award. The court holds that a "personal injury," for which compensation may be compelled under the law, must embrace both an unlooked-for mishap and bodily injury. (Linnane vs. Aetna Brewing Co., 99 Atlantic Reporter, 507).

# Some Factors in Condenser Practice*

By Charles H. Bromley†

*SYNOPSIS—Gives a bibliography of the important papers on condensers and on heat transmission as related chiefly to condensers. Heat-transmission rates, tube arrangements, tube corrosion, water velocities, resistance to steam flow, etc., are dealt with by the speaker.*

The purpose of my remarks is merely to place before the meeting some of the chief features of steam-condenser practice as done in some modern stations. The occasion does not warrant greater breadth of discussion, as considerable research work in the field has been done and the data published. Those interested are referred to the following short bibliography on the subject, which so far as I know has never been published.

One taking up the study of steam condensers will find it well worth while to study the paper by Osborne Reynolds, on "The Extent and Action of Heating Surface for Steam Boilers," Literary and Philosophical Society, Manchester, England, 1874. Nearly all of the investigators who followed Reynolds have elaborated upon the laws of heat transfer, as laid down by him in this paper. Another excellent paper on the subject is by Dalby, on "Heat Transmission," British Institute of Mechanical Engineers, 1909. This paper gives references to over 500 papers on the general subject of heat transmission. To continue with the bibliography:

P. E. Stanton, "Passage of Heat Between Metal Surfaces and Liquids in Contact with Them," Philosophical Transactions, Royal Society of London, Vol. 190, 1847; "Theory of the Surface Condenser," a series of articles in London "Engineering," Jan. 2, 19, 23 and 30, 1914.

Wilson, "The Basis for Rational Design Heat Transfer Apparatus," Transactions American Society of Mechanical Engineers, Vol. 37.

Loeb, "Heat Transmission and Tube Length in Marine Feed-Water Heaters," Journal American Society Naval Engineers, May, 1915.

Babcock & Wilcox Co., "Rate of Heat Transfer from Hot Gas to Cooler Metallic Surfaces," published by Babcock & Wilcox Co., 1916.

H. P. Jordan, a paper on heat transfer in condenser practice, Proceedings of the Institute of Mechanical Engineers, 1909.

George A. Orrok, "Transmission of Heat in Surface Condensers," Transactions American Society of Mechanical Engineers, 1912.

The following four authors have prepared important papers on the effect of air in surface condensation:

J. A. Smith, London "Engineering," Oct. 7, 1904; Victorian Institution of Engineers, December, 1905.

D. B. Morison, Transactions Institute Naval Architects, Vol. 50, p. 170.

William Weir, Transactions Institute Engineers and Shipbuilders in Scotland, November, 1912; Transactions American Society Mechanical Engineers, Vol. 34, 1912.

George A. Orrok, Transactions American Society of Mechanical Engineers, Vol. 34, p. 713, 1912.

Other interesting papers are:

Weighton, "Experiments on Contraflo Condenser," Transactions Institute Naval Engineers, Vol. 48, 1906.

Neilson, "Design of Surface Condensers," Institute Engineers and Shipbuilders in Scotland, 1910; "Diameter of Condenser Tubes," London "Engineering," Jan. 21, 1910.

George A. Orrok, "Proportioning of Surface Condensers," Transactions American Society Mechanical Engineers, Vol. 37, 1916.

Gibson and Bancel, "Performances of Surface Condensers," Transactions American Society of Mechanical Engineers, Vol. 37, 1916.

Except where the character of the water is so extremely bad as to make tube-renewal costs extraordinarily high, the surface condenser is widely used. Nearly all of the large condensers in the modern stations have 1-in. diameter, No. 18 B.w.g. tubes of Admiralty composition, which is 70 per cent. copper, 29 per cent. zinc and 1 per cent. tin, having a thickness of 0.049 in. The tubes are usually heat-treated to relieve fiber stress and reduce the susceptibility to corrosion. Tubes of ¾ and ⅞ in. are not uncommon, and where the circulating water carries much suspended matter, tubes of 1¼ in. sometimes give much longer service than smaller sizes. At the Sixty-sixth Street plant of the Edison Electric Illuminating Co., of Brooklyn, N. Y., where the water is not only corrosive but high in suspended matter, several years' experience have convinced the engineers that 1¼-in. tubes of Admiralty composition give the longest service. A condenser with 1¼-in. tubes had been, at my last visit to the station, in service four years without a cent having been spent on it for tube renewals. This is by no means an extraordinary life for a tube, but it is a long time for tubes to continue in service with the water conditions that prevail in that part of the East River.

Usually the tubes are expanded into one tube plate, the joint at the other plate being packed with fiber washers and corset lacing, which in the more modern stations is put in by machines.

Engineers and condenser designers reveal by their present practice that their practice of but a few years ago of providing so little tube area as to call for extremely high rates of heat transfer is undesirable. In justice to condenser designers it may be said that the engineers of many of the larger power stations considerably modify at times the design of the condensers as laid out by the condenser builders. The following table shows the condensing surface per killowatt of turbine capacity, as found in some of the modern power stations:

| Station | Turbine Capacity, Kw. | Condensing Surface, Sq.Ft. | Condensing Surface, per kw. |
|---|---|---|---|
| Waterside 2 (New York City) | 22,000 | 25,000 | 1.14 |
| Gold Street (Brooklyn) | 22,000 | 35,000 | 1.59 |
| Fisk Street Station (Chicago) | 25,000 | 40,000 | 1.60 |
| Northwest (Chicago) | 30,000 | 50,000 | 1.66 |
| Connors Creek (Detroit) | 20,000 | 32,500 | 1.62 |
| Seventy-fourth Street (New York City) | 30,000 | 50,000 | 1.67 |
| River (Buffalo) | 20,000 | 33,000 | 1.65 |
| Waterside 2 (New York City) | 30,000 | 50,000 | 1.66 |
| Boston Elevated | 35,000 | 50,000 | 1.43 |

Unfortunately the table does not give the pounds of steam per hour which the condenser in each case was guaranteed to condense. Time did not permit of getting this information; but as the earlier machines first listed in the table had a higher water rate per kilowatt-hour than the turbines of higher capacity and mentioned later, the table serves the purpose intended.

From 300 to 325 B.t.u. per sq.ft. per hr. of tube surface per degree mean temperature difference of the circulating water is now considered the most desirable practice in condenser design.

Condensers are usually provided with considerably more tube surface per unit weight of steam to be condensed than is theoretically required, owing to much of the surface being inactive even in the best-designed condenser and to the tube accumulating dirt and scale. Tubes frequently and unfortunately get dirty; the rate of heat transmission is accordingly reduced and the vacuum becomes insufficient for efficient main unit performance. A uniformly high vacuum over operating periods is worth far more than the initial investment saved by reducing the tube surface, provided, of course, that the best arrangement of steam paths into the tube bank is made. Like all matters of engineering, success is a scientific compromise.

Perhaps no detail of condenser design is in need of and is receiving more attention than that of providing steam paths into the tube bank. The lower tubes particularly are surrounded with films of water and dense air, seriously impeding heat flow through those tubes. Baffling to direct water and vapor away from the tubes, to give what is called "dry tube" surface, is becoming less favorably regarded by engineers. Experience has shown that it is quite difficult, maybe commercially too difficult, to produce effective results with baffling without so much increasing resistance to the flow of steam into the tube bank as to be seriously objectionable. Engineers are holding designers to a drop of 0.2 in. of mercury from the main-unit exhaust nozzle to the air-pump suction nozzle.

At Connors Creek a 35,000-sq.ft. condenser after providing paths in the tube bank, was reduced in tube surface to 32,500 sq.ft., giving better results. Comparatively little baffling is used in this condenser. (See "Power," Sept. 14, 1915, p. 392.) Vertical paths, especially in the upper part of the condenser with baffles only well down toward the bottom, are finding most favor. If they lent themselves better to turbine-foundation construction, I believe that highly desirable results would be had with wide, shallow condensers.

*Abstract from talk before joint meeting of Boston sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, Apr. 5, 1917.

†Associate editor, "Power."

George Orrok showed in his paper, "Air in Surface Condensation," Transactions American Society of Mechanical Engineers, Vol. 34, 1912, that an adequate open feed-water heater will reduce the air in the feed-water probably not to exceed 1 per cent. of the feed-water volume. Showing the importance of stopping air leaks into the condenser, Orrok gives the air discharged by the air pump for units between 5000 and 20,000 kw. as from 1 cu.ft. per min. when units are tight to 15 or 20 cu.ft. per min. with ordinary leaks and 30 to 50 cu.ft. when units are in bad condition.

The hydraulic air pump is now most widely used; but the modern stations install a reciprocating air pump and air-measuring equipment to test for air leakage from time to time. This is considered a good investment.

Tubes are now generally packed with fiber washers and corset lacing. Fiber ferrules are giving excellent results when driven in tightly. When wet, these swell and make a tight and durable joint. The rubber ring is not widely used. The corset-lace-packed tubes are packed by pneumatic tools in at least one station I know of.

A water velocity that will keep the tubes free of foreign substances and yet not penalize the circulating water pumps seems to have settled down to 6 to 10 ft. per sec., 8 ft. being favorably regarded.

The steam consumption of the condenser pumps—that is, circulating, condensate and air—will of course vary with tube conditions, condition of impellers and air leaks. About 7 per cent. of the main unit consumption is considered good in estimates. This may, however, increase, owing to the lowering of water rates in the large turbines, although 35,000 kw. is the limit at which capacity tends to lower the water rate.

The most baffling part of condenser practice is tube corrosion. Reams of data have been collected, and we seem to know little more than we did several years ago before its collection. Broadly, the Admiralty tube, 70 per cent. copper, 29 per cent. zinc and 1 per cent. tin, gives longest life. In and about New York City these tubes last from 4½ and 6 years on the upper North River to 3 years and less on the lower East River. With water not contaminated with sewage and vegetable compounds, tubes last considerably longer.

John P. Sparrow, chief engineer of the New York Edison Co., made some valuable experiments with condenser tubes of aluminum bronze consisting of 92 per cent. copper and 8 per cent. aluminum. Briefly, the results were these: Excellently homogeneous tubes were made when this metal was hard-drawn and properly annealed. The internal stresses were likely negligible in tubes drawn and so heat-treated, their susceptibility to corrosion was minor and they gave excellent service and longevity. But the workmanship, the mill treatment of these tubes, was so irregular as to make them on the average most unreliable; that is, the microstructure in one order of such tubes would vary all the way from extremely bad to extremely good, with no assurance of what you were going to get. Monel-metal tubes experimented with by Mr. Sparrow corroded; but I will qualify this by saying that I do not know of what metal the tube sheets or the condenser shell was in which these monel tubes were used.

## Interpretations by the Boiler Code Committee

The Boiler Code Committee of the American Society of Mechanical Engineers meets monthly for the purpose of considering communications relative to the Boiler Code. Following are some recent interpretations of the committee:

Copies of the Boiler Code may be purchased from the society, 29 West 39th St., New York City. For nonmembers the cost is 80c. per copy; for members, 40c.

Case No. 76 (Reopened)—Inquiry: What net area should be considered in calculating stay-bolts with telltale holes drilled in their ends? Also an opinion is requested whether, in determining the load on a bolt, the full pitch dimensions of the area stayed should be used or the area occupied by the bolt itself should be deducted.

Reply: The question as to the area of a drilled stay-bolt is answered by Par. 220, which specifies clearly the net cross-sectional area of the stay. The full pitch dimensions of the stays should be employed in determining the total area, and the area occupied by the bolt itself may be deducted to determine the net area to be supported by the stays and the load carried by the stays.

Case No. 116—Inquiry: In the case of safety valves, does the second sentence of Par. 286 require the raised face specified as a detail in Tables 15 and 16 of the Appendix? Would it not be better practice to make the boiler flanges of all safety valves flat-faced?

Reply: It is the opinion of the committee that flanged cast-iron pipe fittings used for boiler parts, for pressures up to and including 160 lb. per sq.in. shall conform to the American Standards given in Tables 15 and 16 of the Appendix, except that the face of the flange of a safety valve, as well as that of a safety-valve nozzle, shall be flat and without the raised face. The face of the flange of a safety valve, as well as that of a safety-valve nozzle, shall have a flat face for pressures up to and including 250 lb. per sq.in. and shall have a raised face at higher pressures.

Case No. 124—Inquiry: (a) Where reinforcing of heads is provided for as in locomotive-type boilers, the heads being braced by separate plates, what material may be used for this reinforcing plate, as well as also for the gusset plates? (b) Does Par. 269 allow the use of two safety valves whose combined area is equal to the 3-in. valve? (c) Is it allowable under Par. 182 and 183 to insert a row of stay-bolts through the center of a joint, the spacing to be as in outer row?

Reply: (a) It is the opinion of the committee that this question is answered by Par. 2 and 5 of the Boiler Code, flange steel being acceptable where not exposed to the fire or products of combustion. (b) The intent of Par. 269 will be expressed by adding the following words to the paragraph: "In which case one or more safety valves may be used." (c) A row of stay-bolts is allowable through the center of a joint provided the requirements in the Code as to back pitch of rivets and dimensions of ligaments are met, by considering a stay-bolt or other hole in the same way as a rivet hole. Where the plates at the two ends of a stay are of different thickness, the pitch must equal the thinnest plate.

Case No. 127—Inquiry: An interpretation is requested of Par. 323, 324 and 325 in their application to different types of boilers. If Par. 325 is to be used in conjunction with Par. 323 and 324 and refers to return-tubular boilers only, should this not be so stated?

Reply: It is the opinion of the committee that Par. 325 refers to any type of boiler.

Case No. 128—Inquiry: An explanation is desired of the conflict that appears to exist between Par. 12 and 268 of the Boiler Code in their application to the use of cast-iron nozzles.

Reply: It is the intent of the rules in the Boiler Code not to allow the use of cast-iron nozzles riveted to the shell of a steam boiler for any temperature or pressure.

Case No. 129—Inquiry: In view of the difficulty at the present time of securing iron boiler tubes to meet the Code specifications, permission is requested to use wrought-iron tubes which, on account of their small diameter, cannot meet the flanging test?

Reply: The requirements of the flanging test for wrought-iron tubes will be changed in the forthcoming revision of the Code. They will be so modified as to make it possible for acceptable wrought-iron tubes to meet them.

Case No. 130—Inquiry: A ruling is requested covering the staying of crown-sheets of furnaces of locomotive-type boilers by means of a special form of arch bar which is attached to the crown-sheet by stays spaced at regular intervals.

Reply: There are no rules in the Boiler Code for arch bars of the special type referred to. There are rules given in Par. 230 for straight crown bars and girder stays, which would have to be modified to apply them to these special arch bars. Where furnaces require staying Par. 212 of the Code specifies that they shall be stayed as flat surfaces. The rule for staying flat surfaces is given in Par. 199, and the maximum pitch of staybolts at different working pressures and for different thicknesses of plate is given in Table 3. These rules and the values in the table would apply in the case of the stays used between the top of the furnace and the arch bars, the pitch to be used being the maximum, measured either between the rows of stays in the arch bars or between the stays in a given arch bar. By applying the rules for stays the allowable working pressure can be determined if the crown bars are made strong enough and are properly supported at their ends.

Case No. 131—Inquiry: Will a 1½-in. brass-body safety valve be acceptable on the outlet from a superheater provided it conforms to all other requirements of the Boiler Code?

Reply: It is the opinion of the committee that under Par. 289 the use of brass-body safety valves is not permissible.

Case No. 132—Inquiry: Is Par. 321 intended to apply to the fittings on water columns as well as to the pipe connections? In other words, can extra-heavy cast-iron crosses be used for the fittings instead of brass crosses?

Reply: It is the opinion of the committee that Par. 321 applies to the fittings as well as the pipe connections. Therefore cast-iron crosses or other fittings will not be permissible.

Case No. 135—Inquiry: Is it permissible to make use of patch bolts instead of rivets in fastening the flanged edges of the sheets in a door hole of a locomotive-type boiler, where accessibility to the work for riveting is impossible?

Reply: Where there is insufficient room to use rivets, such as in the specific case mentioned, the Boiler Code does not prohibit the use of patch bolts.

# -Properties of Metals and Alloys

The Bureau of Standards, Department of Commerce, at Washington, D. C., is undertaking to compile the present state of knowledge and practice concerning the numerical values used by engineers and others for the properties of metals and alloys, with a view to making generally available the most acceptable values of these constants and also as a basis for further experimental investigation.

The following illustrates in outline a few of those cases concerning which information is sought, and the bureau asks the addition of such other metals and alloys concerning which anyone may have or desire information. In each case the numerical values considered representative and fair rather than special values are desired.

The bureau asks and will appreciate the coöperation of all in assembling these data, which will be of great service in framing and interpreting specifications involving the use of metals.

The following should be borne in mind in filling in and completing the table:

1. Chemical composition should be known to apply strictly to alloy for which properties are given.

2. The state of the metal as cast, annealed, forged, rolled, etc., should be given in as great detail as possible.

3. The authority or source for all numerical values should be given.

4. The limits or tolerances which should be allowed or expected in practice for any constant should be given. These may be indicated on line immediately below best value or values.

5. Where maximum values only occur, they may be prefixed by **a**, minimum values only by **b**.

6. When not self-evident, the unit should be given in which a constant is expressed. Size and description of test pieces should be given.

7. When possible and known, the variation with temperature of any property should also be given.

8. Data on the effect of impurities on any of the physical properties of any metal or alloy will be greatly appreciated.

9. Additional forms will be furnished as desired.

10. As illustrative of what is wanted, a sheet giving the properties of copper is inclosed. Criticisms of the constants for copper are desired.

11. Some of the alloys for which data are desired are the following: Aluminum and its light alloys with zinc, copper, etc., of stated percentages; nickel, monel metal, and copper-nickel alloys; aluminum bronzes, such as Al 7-Cu 93, Al 10-Cu 90, etc.; manganese bronzes, cast and wrought; phosphor-bronzes, such as Cu 80, Sn 12, Pb 7, Pl, etc.; muntz metal, naval brass, tobin bronze, and brass of 60 Cu-40 Zn; yellow brass of 70 Cu-30 Zn, the red brasses and other brasses; bronzes of 90 Cu-10 Sn, 88 Cu-10 Sn-2 Zn, 88 Cu-8 Sn-4 Zn, and their modifications with Pb and Fe added, etc.; bearing metals; white metals, etc.

12. Similar data on any other metals or alloys will be greatly appreciated.

Following is a specimen sheet partly filled out for the alloy named. The general arrangement should be copied.

| Name of metal or alloy..... | Commercial electrolytic copper | | | |
|---|---|---|---|---|
| State or condition..... | Cast | Annealed | Hard Drawn | Remarks |
| Chemical composition and impurities..... | 99.90% Cu, 0.08% $O_2$, 0.002% Pb, 0.002% Ag, 0.003% Fe. | | | 0.0005% As, |
| Density, g. per $cm_3$..... | 8.89 | | | |
| Shrinkage coefficient, %.... | 1.42 | | | |
| Tensile strength, lb. per sq.in..... | 20–30,000 | 30–40,000 | 40–60,000 | Ranges of commercial variations |
| Yield point, lb. per sq.in.... | | | | |
| Elastic limit, lb. per sq.in... | | | | |
| Elongation in 2 in., %..... | 30–50 | 40–60 | 4–5 | |
| Reduction of area, %..... | 30–50 | 40–60 | | |
| Brinell hardness, H.N..... | 30–40 | 30–40 | 80–100 | |
| Scleroscope hardness..... | | 6–7 | 22–24 | |
| Behavior in compression.... | Yields indefinitely and flattens out | | | |
| Frictional coeff. (steel)..... | | | | |
| Abrasion resistance..... | | | | |
| Melting range, deg. C. or F., 1083.0 deg. C..... | | | | |
| Coeff. of expansion, per deg. C..... | 0.00001666 | | | |
| Specific heat..... | 0.0917 (25 deg. C.) | | | |
| Cal. per g. degree..... | Sp.h. = 0.01917 + 0.000048 (t–25) | | | |
| Thermal conductivity..... | $3.73 \left(\frac{\text{watt-seconds}}{\text{cm.-second-deg. C.}}\right)$ | | | |
| Electrical conductivity ohms (meter, gram)..... | 30–90% | 100% = 0.15328 | 96–97% | |
| Temp. resistance coeff. per degree C..... | 0.0000393 | | | |
| Resistance to corrosion..... | | | | |
| Hydraulic properties..... | | | | |
| Optical properties Emissivity for $\lambda = 0.65\ \mu$ (for liquid (1100 deg. C.) = 0.150 (for solid (1080 deg. C.) = 0.117 | | | | |
| Miscellaneous (including any other known property)... | | | | |

# NEW PUBLICATIONS

PRELIMINARY MATHEMATICS. By Prof. F. E. Austin. Published by the author, Hanover, N. H., 1917. Cloth; 4½ x 7 in.; 169 pages. Price, $1.20.

According to the author's preface this book is intended to provide a connecting link between the study of arithmetic and algebra and was originally prepared for the use of those whose education has been limited, but the text has been remodeled so as to adapt it for high-school students. The chief object of the work is to show how to solve problems. The first 77 pages treat of arithmetic, elementary algebra and logarithms. Many problems are given to be worked out by the student, but unfortunately the answers are not given, therefore they are of little value to the student who cannot consult an instructor. The second part of the work covers the various algebraic equations up to and including simultaneous quadratics, also arithmetical and geometrical progression. This part of the book is devoted chiefly to showing how to work out problems. The author has made the mistake of trying to cover too many subjects in the allotted space, therefore much of the treatment is superficial.

Although it is pointed out in the preface that the book is to be used as an auxiliary with other textbooks and that many points are explained that are passed over in ordinary texts, nevertheless many parts of the work seem to be inconsistent. If the student's mathematical knowledge is so limited that he must be told what a division sign is, it does not appear possible that he will be prepared to intelligently solve problems involving positive and negative exponents 10 pages farther on in the work.

WIRING FOR LIGHT AND POWER. By Terrell Croft. Published by the McGraw-Hill Book Co., Inc., New York, 1917. Flexible cover; 5 x 7½ in.; 426 pages; 382 illustrations. Price, $2.

No doubt everyone who has done electrical work has experienced, at one time or another, the need of some guide as to what was the correct interpretation of the National Electrical Code or how a certain class of work is generally executed. Although the National Electrical Code is the most comprehensive compilation of rules for the installation of electric wiring and devices, nevertheless it is superficial in many of its specifications and need be so to cover the broad field that it does. Mr. Croft in his book seems to have thoroughly covered the subject of the National Electrical Code, not only in the interpretation of the rules, but also in showing how the work should be done to conform with the regulations laid down therein. The book has incorporated in it verbatim the most important rules of the code. Each regulation is explained by applying it to some example of practical electrical construction. The 382 illustrations are one indication of the comprehensiveness of the work. There are 248 questions given pertaining to the code. This feature should be very helpful to those wishing to obtain an electrician's license, such as required in certain localities. The subjects are thoroughly indexed, 25 double-column pages being devoted to this matter, making it easy to locate any particular subject treated in the work. What the practical electrical man for many years past has been looking for seems to be incorporated in this book, and it should not only find an exceptionally wide field of usefulness among electrical workers in general, but also make an excellent text for use in industrial schools giving a course of instruction in electrical work.

ELECTRIC CENTRAL DISTRIBUTING SYSTEMS. By H. B. Gear and P. F. William. Published by D. Van Nostrand Co., New York, 1917. Cloth; 5½x8 in.; 457 pages; 187 illustrations; 26 tables. Price, $3.50.

The rapid change in the conditions under which electric current is distributed and the progress made since the appearance of the first edition of this work in 1911 have necessitated this second edition, which has been thoroughly revised, enlarged and brought up to date. The first edition contained only 347 pages, against 457 in this one. The work treats of the design and construction of electrical central-station distribution systems and is divided into 25 chapters, embracing the following subjects: Systems of distribution, transmission systems, substations, voltage regulation, line transformers, secondary distribution, special schemes of transformation, protective apparatus, overhead construction—pole lines, overhead construction, lines and accessories, underground construction, cable work, distribution economics, properties of conductors, and alternating-current circuits.

The chapter on special schemes of transformation contains many useful diagrams of transformer connections, not only standard single- and three-phase connections, but also special applications of transformers as booster and phase transformation. A 60-page chapter is given to the subject of distribution

economics and embraces the selection of economic sizes of conductors, minimum annual cost, fixed charges, losses and their calculations, determination of the best size of conductors for different typical cases, diversity factor for different classes of customers, diversity at different points in the system, total diversity factor for light and power users and rate systems; examples are given to show the application of the subjects treated. The subject matter throughout the work is representative of American practice entirely, and the treatment is based on the assumption that the reader has a general knowledge of electrical theory, such as is possessed by the more advanced students of electrical engineering and by practical distribution engineers. However, a large percentage of the material is of such a nature as to be easily grasped by the practical man, and the book should be well received by electrical workers in general.

N. E. L. A. RATE BOOK

The N. E. L. A. Rate Book and Supplements for 1917, published by the Rate Research Committee of the National Electric Light Association, 29 West 39th St., New York City, has been recently issued. This book gives the principal electric lighting and power rates of companies operating in cities of the United States and Canada of 40,000 in population and upward. The states are arranged alphabetically, likewise the cities in each state. Under each city is given such information as how the energy is generated, population, rates, determination of demand, prompt-payment discount, minimum charge, lamp service, term of contract, etc., for resident lighting, commercial lighting, hotel lighting and power, display lighting, retail power, wholesale power and lighting service, etc. To exemplify the names of the rates given throughout the book, the editors have given and worked out examples of the various rate forms. The masterly way in which this compilation of rates has been presented is an accomplishment on which the Rate Research Committee of the N. E. L. A. and the editors are to be complimented.

## Appoints Board of Boiler Rules

Pursuant to the recent act of the New Jersey Legislature providing for a Board "to formulate rules and regulations for the safe and proper construction and use of steam boilers, Governor Edge has appointed Franklin Van Winkle, of Paterson, consulting engineer and Associate Editor of "Power," and Frank W. Casler, of Newark, superintendent of power plants for the Public Service Corporation of New Jersey. These gentlemen will serve jointly with the members of the Steam Engine and Boiler Operators' License Bureau and the Commissioner of Labor, the whole constituting the Board of Boiler Rules.

## PERSONALS

**R. D. Tomlinson** is now superintendent of the General Abrasive Co., Inc., at Niagara Falls, N. Y.

**James T. Edwards,** of Pittsburgh, has been appointed chief engineer of the Niagara, Lockport and Ontario Power Co., of Lyons, N. Y., in place of George Sterling, resigned.

**Prof. William D. Ennis,** since 1907 head of the department of mechanical engineering in the Polytechnic Institute of Brooklyn, was appointed major in the Ordnance Section, Officers' Reserve Corps, May 5, 1917.

**T. F. Webster,** for 25 years associated with the Link-Belt Co., and for the last 12 years manager of the company's Pittsburgh (Penn.) office, has resigned to become vice president of R. H. Beaumont Co., Philadelphia, builders of conveying and hoisting systems.

**Maxwell C. Maxwell,** formerly superintendent of power and plant and of the tool and machine department of the Yale & Towne Manufacturing Co., Stamford, Conn., has been appointed assistant general superintendent of that organization. A. O. Blackman has been made superintendent of power and plant, and J. B. Freysinger, superintendent of the tool and machine department.

**J. D. Vail,** former manager of the Salt Lake City office of the H. W. Johns-Manville Co., has been appointed manager of the building-materials department of the company's branch at Chicago. C. F. Cate will hereafter manage the Salt Lake City office, and J. H. Roe will manage the Great Falls (Mont.) office.

**A. H. Sweetnam,** formerly designing engineer with Sargent & Lundy, Chicago, and more recently connected with the engineering department of the Commonwealth Edison Co., Chicago, has resigned to enter the engineering department of the Stone & Webster Engineering Corporation, at Boston, Mass.

**B. H. Collins,** well known in the advertising agency field, has joined the publicity staff of the Society for Electrical Development. Mr. Collins takes the place of Hill Griffith, first lieutenant, cavalry, Officers' Reserve Corps, who has been called into active service.

**Frank B. Broadhurst,** for many years general sales manager of the C. H. Wheeler Manufacturing Co., has joined W. G. Starkweather, and under the firm name of Starkweather & Broadhurst they will continue as New England representatives of the C. H. Wheeler Manufacturing Co., A. L. Ide & Sons and the Union Iron Works.

## ENGINEERING AFFAIRS

**The Iowa Section, National Electric Light Association,** will hold its annual convention at Des Moines, Iowa, May 24-25.

**The National District Heating Association** will hold its ninth annual convention in Detroit, June 12-15, with headquarters and convention exhibits at the Pontchartrain Hotel.

**The Pittsburgh (Penn.) Section of the Association of Iron and Steel Electrical Engineers** will hold a meeting on June 16 at Monongahela House. James Farrington will talk on "By-product Coke Ovens in the Steel Industry."

**The John Fritz Medal,** which is awarded from time to time for notable scientific or industrial achievement, was awarded to Dr. Henry Marion Howe, January, 1917, for his investigations in metallurgy, especially in the metallography of iron and steel. The presentation took place in the auditorium of the United Engineering Societies Building, New York, Thursday, May 10. Ambrose Swasey, chairman of the John Fritz Medal Board of Award, presided. He introduced Dr. Rossiter W. Raymond, secretary emeritus of the American Institute of Mining Engineers, who delivered an address on "The Genesis of a Science" and reviewed the achievements of Dr. Howe. Dr. Ira N. Hollis, president of the American Society of Mechanical Engineers, was then introduced and took for the subject of his address, "The Value of Scientific Research." Judge Elbert H. Gary, chairman of the Board of the United States Steel Corporation, was to have taken part in the ceremonies, but was unable to do so on account of the many pressing demands of these critical times. The medal was presented to Dr. Howe by Prof. Albert Sauveur, after which the ceremonies were concluded by a response from Dr. Howe.

## TRADE CATALOGS

**Oil Tanks, Pumps and Storage Systems.** Gilbert & Barker Manufacturing Co., Springfield, Mass. Set of Bulletins; 8 x 10 in.; illustrated.

**Steam Jet Conveyor Systems.** American Steam Conveyor Corporation, 326 West Madison St., Chicago, Ill. Catalog; pp. 32; 8 x 10 in.; illustrated. Contains line drawings and photographs of typical installations.

**Spraco Products.** Spray Engineering Co., 93 Federal St., Boston, Mass. Condensed catalog of spray cooling, air washing and cooling and paint-spray equipment, flow meters, nozzles; pp. 16; 8 x 11 in.; illustrated.

**Duplex Steam Pumps.** Dean Bros. Steam Pump Works, Indianapolis, Ind. Circular No. 104; pp. 8; 8½ x 11 in.; illustrated. This shows the design and construction of these pumps and should be of value to those interested.

**Reducing Vibration and Noise.** Armstrong Cork and Insulation Co., Pittsburgh, Penn. Booklet; pp. 32; 5 x 7½ in.; illustrated. Describes the application of Nonpareil Cork to fans, motors, etc.

**Diamond Soot Blowers for Babcock & Wilcox Boilers.** Diamond Power Specialty Co., Detroit, Mich. Bulletin No. 125; pp. 12; 8 x 11 in.; illustrated. Contains statement from Babcock & Wilcox Co. telling why that company has adopted Diamond soot blowers as standard equipment on all its boilers.

**"Imperial X" Duplex Steam Driven Compressors.** Ingersoll-Rand Co., 11 Broadway, New York. Form No. 3311. Pp. 20; 6 x 9 in.; illustrated.

**Brownhoist Overhead Hand Traveling Cranes.** The Brown Hoisting Machinery Co., Cleveland, Ohio. Catalog P. Pp. 36; 6 x 9 in.; illustrated. Contains data and tables.

**Leather Belting, Belt Lacing, Belt Cement, Belt Dressing, Etc.** Charles A. Schieren & Co., 30-38 Ferry St., New York. Catalog. Pp. 40; 6 x 9 in.; illustrated.

**Feed-Water Heaters, Purifiers, Steam Separators, V-Notch Water Meters, Etc.** The Hoppes Manufacturing Co., Springfield, Ohio. Catalog No. 70. Pp. 64; 6 x 9 in.; illustrated.

# THE COAL MARKET

**Boston**—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

| | Circular[1] | | Individual[1] | |
|---|---|---|---|---|
| | May 19, 1917 | One Year Ago | May 19, 1917 | One Year Ago |
| Buckwheat | .....* | $2.05—3.20 | $6 00—6.75 | $3 25—3.50 |
| Rice | .....* | 2.50—2.65 | 5.20—5.85 | 2.70—2.95 |
| Boiler | .....* | ..... | .....* | ..... |
| Barley | .....* | 2.20—2.35 | 4.90—5.00 | 2.35—2.60 |

*No prices quoted

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

| | F.o.b. Mines* | | Alongside Boston† | |
|---|---|---|---|---|
| | May 19, 1917 | One Year Ago | May 19, 1917 | One Year Ago |
| Clearfields | $5.75—6.50 | $1.20—1.65 | $10.75—11.25 | $4.25—5.00 |
| Cambrias and Somersets | 6.00—6.75 | 1 50—1.85 | 11.00—11.50 | 4.60—5.40 |

Pocahontas and New River, f.o.b. Hampton Roads, is $7.25—7.50, as compared with $2.75—2.85 a year ago; on cars Boston price is $13.

*All-rail rate to Boston is $2 60. †Water coal.

**New York**—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

| | Circular[1] | | Individual[1] | |
|---|---|---|---|---|
| | May 19, 1917 | One Year Ago | May 19, 1917 | One Year Ago |
| Buckwheat | $4 00—4.15 | $2.75 | $6.50—6.75 | $2.50—2.90 |
| Rice | 3.40—4.05 | 2.25 | 5.00—5.50 | 2.05—2 25 |
| Barley | 2.90—3.10 | 1 75 | 3.75—4.00 | 1.60—1.75 |

BITUMINOUS

| | South Amboy | Port Reading | Mine Price |
|---|---|---|---|
| Clearfield | $7.25—8.00 | $7.25—8.00 | $6.25—6 50 |
| South Forks | 7.50—8.00 | ..... | 6.25—6.50 |
| Nanty Glo | 7.50—8.00 | ..... | 6.25—6 50 |
| Somerset | 7 25—7.75 | 7.25—7.75 | 6.00—6.25 |
| Quemahoning | 7.50—8.00 | 7.50—8.00 | 6.25—6 50 |

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

**Philadelphia**—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

| | Line | | Tide | |
|---|---|---|---|---|
| | May 19, 1917 | One Year Ago | May 19, 1917 | One Year Ago |
| Buckwheat | $2.80 | $1.65 | $3.70 | $2.55 |
| Rice | 2.30 | .90 | 3.30 | 1 80 |
| Boiler | 2.10 | .... | 3 20 | .... |
| Barley | 1.80 | .55 | 2.05 | 1.30 |

**Pittsburgh**—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

| | May 19, 1917 | One Year Ago |
|---|---|---|
| Slack | $4.75—5.00 | $0.95—1.05 |
| Mine-run | 4 75—5.00 | 1.25—1.35 |
| ¾-in. | 4.75—5.00 | 1.35—1.45 |

Add 40c. per ton for freight charge to Pittsburgh.

**Chicago**—Current price per net ton f.o.b. mines are as follows:

| | Williamson and Franklin Counties | Saline and Harrisburg | West Virginia Smokeless | Springfield | Clinton and Sullivan Counties |
|---|---|---|---|---|---|
| Steam lump | $3.00—3.50 | $2.75—3.00 | $4.50—5.25 | $3.00—3.25 | $3.25—4 00 |
| Lump | 3.25—3.75 | 3.25—3.75 | 4.75—5.50 | 3.00—3.25 | 3.50—4.00 |
| Egg | 3.25—3.75 | 3 25—3.75 | 4.75—5.50 | 3.00—3.25 | 3.50—4.00 |
| Nut | 3.25—3.75 | 3.25—3.75 | ..... | 3.00—3.25 | 3 50—4.00 |
| No. 1 nut | 3.25—3.75 | 3.25—3.75 | ..... | 3.00—3.25 | 3.50—4 00 |
| No. 2 nut | 3.25—3.75 | 3.00—3.50 | ..... | 3.00—3.25 | ..... |
| No. 3 nut | 2.75—3.25 | ..... | ..... | ..... | ..... |
| No. 1 washed | 3.25—3.75 | ..... | ..... | ..... | ..... |
| No. 2 washed | 3.25—3 75 | ..... | ..... | ..... | ..... |
| Mine-run | 2.75—3.25 | 2.50—3.00 | 4.50—5.25 | 3.00—3.25 | 3.50—4.00 |
| Screenings | 2.75—3.75 | 2.75—3.25 | ..... | 3.00—3.00 | 3.50—4.00 |

Hocking lump, $4.50—4.75; splint lump, $4.50—4.75.

**St. Louis**—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

| | Williamson and Franklin Counties | | Mt. Olive and Staunton | | Standard | |
|---|---|---|---|---|---|---|
| | May 19, 1917 | One Year Ago | May 19, 1917 | One Year Ago | May 19, 1917 | One Year Ago |
| 6-in. lump | $3.50 | $1.40 | $2.25 | $1.35 | $2.75 | $1.15 |
| 2-in. lump | 3.50 | 1.25 | 2 25 | 1.20 | 2.50 | .95 |
| Steam egg | 3.50 | 1.25 | 2.25 | 1.20 | 2.50 | .95 |
| Mine-run | 3.25 | 1.25 | 2.25 | 1.10 | 2.25 | .95 |
| No. 1 nut | 3.50 | 1.40 | 2.50 | 1.20 | 2.50 | .95 |
| 2-in. screen | 2.75 | 1 25 | 2.25 | 1.10 | 2.00 | 1 05 |
| No. 5 washed | 2.75 | 1.15 | 2.25 | 1.10 | 2.00 | 1.00 |

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

**Birmingham**—Current prices per net ton f.o.b. mines are as follows:

| | Mine-Run | | Mine-Run |
|---|---|---|---|
| Pratt | $3.75—4.00 | Carbon Hill | $3.75—4.00 |
| Big Seam | 3.25—3.50 | Cahaba | 3.75—4.00 |
| Black Creek | 3.25—3.50 | | |

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

# PROPOSED CONSTRUCTION

**Ariz., Yuma**—F. L. Ewing has applied to the City Council for permission to build a power line through Yuma from the Colorado River to Yuma Ice plant.

**Calif., Pasadena**—City Commission passed ordinance providing the installation of an electric-lighting system on Lester Ave., between Orange Grove Ave. and Roseila Drive.

**Iowa, Little Rock**—The City Council plans to establish an electric-light plant.

**Iowa, Sioux City**—The Sioux City Service Co. plans to construct a $750,000 power plant.

**Kan., Douglass**—City plans to issue $5000 bonds to provide for the establishment of an electric-lighting system.

**Kan., Ellis**—City voted in favor of issuing bonds to improve the electric-light plant.

**Kan., Prescott**—City is considering installing an electric-lighting system.

**Ky., Butler**—C. E. Record has obtained a 20-year franchise for furnishing electric service here, and is completing plans for the erection of a power plant. Estimated cost $5000.

**Ky., Elkhorn**—M. Bolling and others plan to organize a company for constructing an electric light and power plant. Estimated cost $15,000.

**Md., Baltimore**—The General Utilities and Operating Co., Munsey Bldg., has increased its capital stock from $1,500,000 to $3,000,000, and will build extensions. F. R. Weller, Hibbs Bldg., Washington, D. C., 2nd Vice Pres. and Gen. Mgr.

**Md., Baltimore**—J. H. & L. A. Dockman, 32 East Montgomery St., plan to erect a power plant at their proposed ice factory at Rock Creek.

**Minn., Sunrise**—The Sunrise Milling Co. will erect an electric-power plant. Plans have been prepared by J. C. Jacobson, 743 Security Bldg., Minneapolis, Minn.

**Mo., Dudley**—City plans to install an electric-lighting system in Dudley, the energy to be obtained from Poplar Bluff.

**Mo., La Plato**—City plans to issue bonds for installing an electric-light plant.

**Mo., Rich Hill**—City is considering installing new generating equipment in the electric-light plant.

**Mo., St. Louis**—The Union Electric Light and Power Co. has been granted a permit to construct a 3-story power plant at 908 St. Charles St. Estimated cost $75,000.

**Neb., Beaver City**—The City Council plans to issue $7000 bonds to increase the output of the electric-light plant.

**Neb., Fullerton**—The Fullerton Electric Light & Power Co. plans to install a gas engine and generator and will also install additional equipment for its hydro-electric plant. W. E. Wolters, Supt.

**Neb., Guide Rock**—R. Brogg plans to extend the local electric distribution system.

**Neb., Superior**—The Southern Nebraska Power Co. will construct a reinforced concrete dam across the Republican River, near Superior, and will install a new generator. Estimated cost, $15,000. F. Youngren, Superior, Engr. Power Sta.

**N. J., Alloway**—Citizens have voted to install an electric-lighting system. Energy to be supplied from the Salem plant of the Electric Co. of New Jersey.

**N. J., Newark**—The Board of Freeholders plans to extend and improve the Electric Light and Power Plant at the County Penitentary.

**N. C., Moorehead**—City plans to install an electric-light plant. C. Smith, Supt.

**N. D., Courtenay**—At the recent city election the $7000 bond issue for the establishment of an electric-lighting plant was approved.

**Ohio, Barberton**—City Council Lighting Comn. plans to install a new boiler and generating equipment. Cost, $61,000 and $48,000 respectively.

**Ohio, Waterville**—The proposal to issue bonds for the installation of an electric distribution system to provide electricity for street lighting, commercial and domestic service carried at a recent election.

**Okla., Carmen**—The City voted $25,000 bonds to construct an electric light and power plant.

**Okla., Custer**—City Council plans to extend the electric-lighting system for supplying electricity in the farming district.

**Okla., Okemah**—City will vote on $20,000 bonds for the improvement of its electric-light plant. Plans are being prepared by the Benham Eng. Co., Colcord Bldg., Oklahoma City.

**Pa., Greenville**—The Pub. Serv. Comn. has granted The Mercer Co. Light, Heat & Power Co. permission to issue $300,000 bonds for extension to their plant. Wm. A. Jaxtheimer, Treas. and Supt.

**Pa., Kingston**—The Pub. Serv. Comn. has granted the Luzerne Co. Gas & Electric Co. permission to issue $270,000 bonds for extending its plant. F. D. Wharton, Pur. Agt., Phila., Pa.

**Pa., Scranton**—The Pub. Serv. Comn. has granted the Scranton Electric Co., 509 Linden St., permission to issue $183,000 bonds for extensions to its plant. M. B. Feldman, Pur. Agt., 30 Church St., New York City.

**S. C. Jefferson**—The Legislature has granted authority for the issuing of $15,000 bonds for an electric-light plant.

**S. D., Plankinton**—City voted $16,000 bonds to purchase the local electric-light plant.

**Va., Franklin**—City plans $10,000 improvements to its electric-light plant, and proposes to change the system from a direct to an alternating current.

**Wis., Potosi**—City is considering installing an electric-lighting system.